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Metallurgical & Chemical Engineering

Volume XIII, Number 16

December 15, 1915

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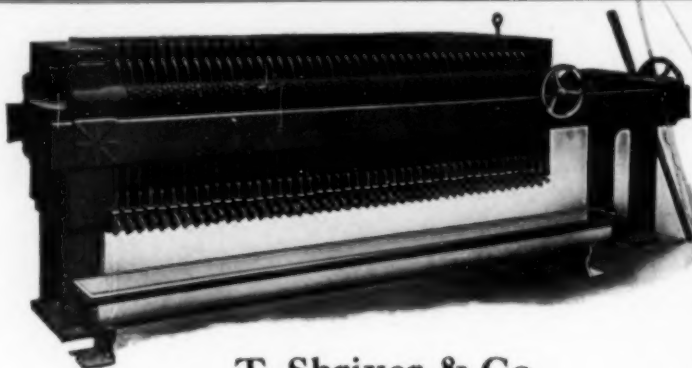
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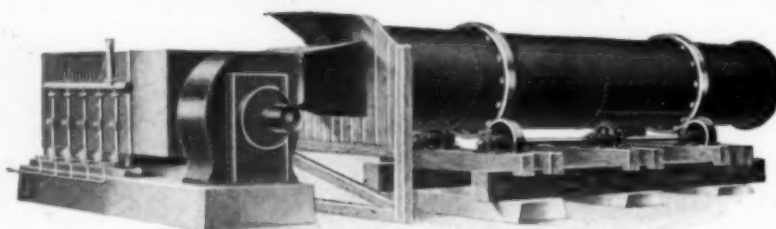
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Alumina in Steel

The article by Mr. G. F. Comstock in our issue of December 1 has apparently a bearing on the problem of steel failures. It seems to be recognized that many failures are caused by the inclusion and segregation of non-metallic impurities. These have been clearly shown by metallographic examination and it has been a general custom to designate them as "slag" inclusions. By some it has been maintained that many so-called "slag" inclusions are really alumina derived from the oxidation of aluminium additions to the steel during the process of manufacture and that these alumina particles show a particularly objectionable tendency to segregate. This, however, could only be regarded as an hypothesis unless some trustworthy method for detecting and distinguishing these as alumina could be devised. Mr. Comstock's paper apparently shows that this can be done and paves the way for reasonable discussion.

The brief letter by Mr. F. A. J. FitzGerald, which we publish in the present issue with respect to Mr. Comstock's article, is refreshing in its frankness and a particularly interesting illustration of what metallographic examinations can reveal.

Lake Superior Iron Ore Prices

An annual event of no little importance in the iron trade occurred on Dec. 8, Lake Superior iron ore prices for the season of 1916 being announced by the merchant ore interests. The prices named represent, broadly speaking, an advance of 75 cents a ton from the schedule that obtained for the 1915 season, that schedule being practically identical with the schedules obtaining in 1912 and 1914, and the lowest since 1904. The 1916 prices are about 50 cents a ton under the schedule ruling in 1907 and 1910, the highest since 1900. The new prices are: Old range Bessemer, \$4.45; old range non-Bessemer, \$3.70; Mesaba Bessemer, \$4.20; Mesaba non-Bessemer, \$3.55, per gross ton, on Lake Erie docks.

Unlike contracts in many branches of the finished steel trade, iron ore contracts are rigidly adhered to. The tonnage sold must be taken. A unique feature of the trade is that instead of payment being made according to delivery the payments are in twelve equal monthly installments, May 1 to April 1, whereas the deliveries, being subject to lake navigation, are chiefly from May 1 to Dec. 1. An interesting feature of the ore contract is that the buyer is given a guaranty that the seller will not sell others at a lower price. Nominally, this is a protection merely given the buyer; practically, it is a safeguard the seller throws around himself.

Improved practice at blast furnaces in recent years in the use of the dusty ores of the Mesaba range is

shown in the decreased price differential between Mesaba and old range ores of non-Bessemer grade. The differential is now well established at 15 cents. From 1905 to 1911 the differential was 20 cents, while in 1902 and 1903 it had been 40 cents. In previous years the differential was apparently less, but in actual fact the dustier Mesaba ores then had no vogue at all. The present 15-cent differential comes about from the desire of the old range producers, not the Mesaba producers. It is not that the Mesaba producer desires to keep his price up, but that the old range producer desires to hold his down, as otherwise he would suffer in the competition by not finding a broad enough market for his product.

High-Grade Spelter "Not Quite So Valuable as Diamonds"

The war has affected all metals and chemicals to a greater or less degree, but one metal indeed erratically. That is the "unusual" metal zinc. The impelling cause lies in the vast amount of spelter used for cartridges both for artillery and small-arms in form of a brass of a mixture 70 per cent copper and 30 per cent zinc suitable for rolling into strips or "discs." The constituent metals of this alloy must have and give peculiar physical and chemical properties, or otherwise cracks, seams and splits occur in the "flowing" and drawing of the metal. Any lack of homogeneity or ductility causes defects. Oxides, sulphides or an excess of lead are specific malignant impurities, although care in casting, rolling and annealing will lessen their effect. A certain number of "rejects" will be made and the cost of manufacture increased. What grade of spelter to use depends largely on the difference in prices, although small-arms cartridges are practically all made from 99.90 per cent spelter. For such class of work as condenser tubes, etc., high-grade spelter is also needed.

For years the production of high-grade spelter has been in the hands of the New Jersey Zinc Co., one of the aristocrats of the metallurgical world, but the "spread" between high-grade and "Prime Western" spelter is so great that several new producers have entered the field for small lots of high-grade which has sold as high as 52 cents, while even now the market is from 30 to 35 cents. The electrolytic zinc works, chief of which are those at Trail and Anaconda, are making a zinc of high purity. The American Zinc Lead and Smelting Co. and the Grasselli Chemical Co. are both producers of spelter analyzing over 99.85 per cent zinc and cadmium. There are others producing a strictly intermediate or 99.75 per cent. The "American" standard "high-grade" calls for 99.90 per cent, Fe 0.03 per cent, Pb 0.07 per cent, Cd trace. Metal like this is produced by the American Smelting and Refining Co. at its Pueblo plant, and by the American Spelter Corporation with works at Kusa, Okla., the latter company being sponsored by Messrs. J. L. de Saulles and G. M. Heckscher.

Whether or not such metal, though made by a process once used at Bertha, will prove equal to Bertha or Horse Head is open for debate. We are inclined to think that though it is an excellent substitute it will not surpass it,

especially for the finest galvanizing. We judge this to be due to what might be termed "geologic individuality." The elements often behave as though they varied with the locality. Arsenious oxide when dissolved in the solvent and precipitated as Paris green, will give under the same conditions products of different properties when from different mines. Fake copper, certain steels, also show evidence of "geologic individuality of the atom," although sometimes the difference comes from minute impurities. Of course, in the case of spelter rare elements like gallium and indium may account for the difference, but "we hae ours doots." However that may be, the pure race of high-grade zinc commands a premium. Saith the buyer to the zinc salesman, "You are trying to sell me something not quite so valuable as diamonds."

How the Steel Market Is Made

Not since 1899 have finished-steel prices displayed such a strongly advancing tendency. The movement of that year cannot be regarded as a precedent or as an illustration, extreme or otherwise, of a market movement in the steel trade, for the steel industry was just finding itself. The period of industrial depression which according to common standards embraced the five years 1893 to 1898 inclusive may be said to have begun earlier in the case of the iron industry, for the pig-iron output of 1890 was not equalled in immediately following years, and during 1890 there was a rapid and extensive fall in pig-iron prices with no substantial recovery in immediately following years. Assuming then that in the iron industry at large the depression began in 1890, the industry entered the depression with wrought iron the dominant product and emerged from it with mild steel as the dominant product. During the depression the change from wrought iron to steel was effected. Some manufacturers, the Carnegie interest being a prominent example, were able to finance the change from wrought iron to mild steel. Others were not. Their plants became effete and dropped out of the reckoning. When demand for the wrought product reached normal, or perhaps slightly supernormal, proportions, the capacity was not available and a veritable boom in prices resulted. General industrial and financial conditions such as obtained in 1899 might recur at any time, but the conditions then existing in the steel industry could not recur, for the steel industry was then for the first time finding its place.

There have been many movements in the steel market since 1899, major movements of which this is the fifth. It is interesting to analyze the conditions that have developed in these movements and attempt to trace the reactions that produced the conditions. In such a study one finds reactions that suggest the catalytic agents as often active in chemical reactions.

Demand and supply are elements in trade which produce reactions, not as chemical elements do through chemical affinity, but through one or the other preponderating. If demand exceeds supply, prices tend to rise. The physical conditions obtaining in the manufacture, distribution and use of steel products are such

that in most finished-steel products it is the jobber or manufacturing consumer who carries the stocks, not the producer. The course of the steel market from year to year has often been strongly suggestive of an underlying trade law, that the carrying of stocks by the producer tends to stabilize prices while the carrying of stocks by the buyer tends to promote fluctuations. One must distinguish between actual ultimate consumptive demand and market demand. The period of prosperity which began early in 1901 and quietly disappeared in 1903 was one of strong consumptive demand. The period extending from late in 1904 to late in 1907 was a similar one, but with the prosperity still more marked. In each case the increase in actual consumptive demand was so marked as to lead to the addition of much productive capacity.

The next two steel-market movements, centering in 1909 and 1912 respectively, were different in extent from their two predecessors, but they were different also in character, in that the demand which causes prices to advance, by being in excess of the offerings, was a market demand not based wholly upon an increased consumptive demand. In each case the inception of the movement found stocks of steel in the hands of jobbers and manufacturing consumers at an extremely low ebb, while later on at the point at which the shipments of mills began to decrease these stocks were much larger, the result of the demand having been partly a market demand and not wholly a consumptive demand. The market demand was created by the fact that prices advanced from time to time and buyers were allowed to place contracts for specification and shipment in future periods. Such contracts would prove profitable to buyers as long as prices should advance.

The extremely heavy consumptive demand in 1905, 1906 and a large part of 1907 prompted the addition of much new productive capacity, and the almost complete collapse in demand that occurred late in 1907 found the steel industry not only with a large capacity, but with much new construction work in progress. Realization of the condition gave the industry a chill from which it did not recover for years, if indeed it is fully recovered even now. New construction has been undertaken with relative timidity since 1907. The market movements of 1909 and 1912 did not produce great waves of new construction. To-day the steel industry finds itself with a smaller increase in capacity over that in existence in 1907 or definitely under construction, than has occurred in any corresponding period in the past.

Given a restoration, or even partial restoration of normal consumptive demand, in keeping with the growth of the country, and an adventitious demand for steel for war purposes abroad, to the extent of a very few million tons a year, the steel industry was at the beginning of this year ripe for another major market movement. The extreme tightness of money late in 1914, coupled with an industrial depression and a continued decline in steel prices, produced the condition that stocks of steel in the hands of jobbers and manufacturing consumers were, in proportion to the size of the steel industry, easily the smallest on record. Con-

ditions were precisely ripe for a market movement, and one based not necessarily upon greatly increased consumptive demand, for the market demand would of itself do much toward carrying a movement along. The steel mills evidently recognized the fact that a market demand could be developed. In several products they followed the policy of naming one price for material if specified once, and another price a dollar a ton higher on a contract that would permit specifying in some later period. For several months the market carried itself along nicely, with this market demand as the chief foundation. Gradually the "war orders" were found to constitute an important tonnage, and actual consumption at home began to increase. Important freight-car orders were placed in May, after many months of practically no railroad buying.

To make a long story short, with increased exports, increased domestic consumption, and a strong market demand due to jobbers and manufacturing consumers being willing to contract ahead, and also if necessary store material in their warehouses, the steel mills eventually found themselves crowded with work.

In analyzing the present condition itself, and the conduct of the market in the past two months, one discovers evidences of catalytic influences already referred to. They do not directly increase or decrease the consumptive demand for steel, or the productive capacity by a single ton, but they affect profoundly the flux of the market. The first is the legal situation, and the mental attitude of sellers of steel, produced by the suit of the government against the United States Steel Corporation, settled in the United States District Court June 3, 1915. The suit developed the fact that sellers of steel should not agree upon market policies. Previously their minds had met at times in an effort to prevent prices from falling, and they had also met at other times to prevent the market's own advancing tendency from carrying prices to a level that might later prove unsafe. The circumstances of the steel suit indicated that such policies ought not to be followed in future and the mental attitude of the steel trade became that it would be just as well, or better, to allow prices to advance as much as they would.

The second catalytic action was the war, and the effects it has produced in trade generally. Spectacular advances have occurred in various commodities. Some of the non-ferrous metals, and many chemicals, are selling at multiples of their former prices. Men's minds are open. Unprecedented advances are regarded as distinct possibilities when everything is so upset. Buyers give countenance to price advances that would be looked askance under normal world conditions.

The catalytic influence of these two elements is beyond question very important in the reactions that are making the steel market. The developments to date are remarkable, and no one knows how much may still occur. From the lowest level since the fore part of 1899 steel prices have risen in a twelvemonth to the highest level since 1907, and yet the prices used for comparison are practically nominal, for the mills accept but a small part of the tonnage offered them.

Readers' Views and Comments

What Metallography Can Show

To the Editor of Metallurgical & Chemical Engineering:

SIR:—An incident in the course of the work reported by Mr. Comstock in his article on "Alumina in Steel" in your issue of Dec. 1 may be of interest as showing the trustworthiness of the conclusions drawn from his micrographic investigations.

The 10-lb. steel ingots used for confirmatory tests were made at the FitzGerald Laboratories by melting the special steel, mentioned by Mr. Comstock, in crucibles made from 6-in. Acheson graphite electrodes and lined with electrically sintered magnesia prepared by the Norton Company. The crucibles were heated in an electric furnace of the kind illustrated in *Electrochemical and Metallurgical Industry*, Vol. III, page 56, Fig. 6, and a new crucible used for every heat unless the melt poured so as to leave the crucible perfectly clean, free from any skull or slag sticking to the lining.

In preparing the ingots treated respectively with aluminium and titanium three heats were made. Of these the first and third were with additions of 0.2 per cent of aluminium, the second with 0.2 per cent titanium in the form of ferro-carbon titanium, but in marking the ingots the sample from the second heat was labeled "No. 3 Titanium," while that from the third was marked "No. 2 Aluminium."

Now in all the experiments the same crucible was used, for the metal poured so cleanly that in no case was an appreciable residue left in the crucible. However, a few days after the sample ingots had been sent to Mr. Comstock an inquiry was received as to whether Sample 2 had not been made after Sample 3 and the same crucible used in both cases, because in addition to the alumina found in Sample 2 a small quantity of titanium nitride was detected in the metal, and this was the only hypothesis to explain its presence.

FRANCIS A. J. FITZGERALD.

The FitzGerald Laboratories, Inc.,
Niagara Falls, New York.

"While You Learn from Mistakes, Make Your Mistakes on a Small Scale"

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In your issue of Nov. 15 I note an editorial entitled "Make Your Mistakes on a Small Scale." The following anecdote illustrating the wisdom of your editorial may interest your readers. It was told me by an old Jew, well versed in the Talmud and in Hebrew lore.

A certain nobleman in Hamburg, Germany, who had inherited title and wealth and had spent his time in the manner of the idle rich, determined quite late in life to speculate on the Hamburg Exchange. His ventures all went wrong. One morning on the floor of the Exchange, he accosted Mr. Moses, an old successful Jewish speculator. "Mr. Moses," he said, "Why is it that in the year I have been a member of this Exchange I have lost money on everything I have touched, and you seem to be making it? It does not seem to me that I am so much less intelligent than you are. Will you not tell me the secret of your success?"

"Oh, yes," said Mr. Moses, "I will be glad to tell you what I think is the reason. When I was a youngster of 13 years of age my father told me that he could not afford to send me to school any longer, and that I must make my own living. He sent me away from the little village where we lived with one dollar, and said, 'My

boy, go out and see whether you cannot make a little money with this dollar.' I left the village and passed an old woman, leaning on the gate of a farm, and I asked her whether she did not have something to sell. She said that she had an old copper kettle for sale. Before purchasing it I went and inquired the price of copper from a junk man and returned to the old woman and asked her to weigh the copper kettle. She did so and I figured that I could make a little money according to the market price of copper and bought the kettle. When I came to sell it, the junk man, to my consternation, would not pay me the price I expected. His reason was a very good one; the copper kettle had a wooden handle, which I had not noticed. I returned to my father in tears, and he consoled me and gave me another dollar. I again went out and purchased a hide. When I came to sell the hide I could not get the price expected, because the hide had no tail, and those special hides without the tail did not command the full price, and again I returned to my father in tears. In this way I paid for my apprenticeship when I was very young and in small amounts. I buy no more copper kettles with wooden handles, nor hides without tails."

Thus spake Mr. Moses and walked away, leaving Mr. Nobleman to reflect on the aptness of the story.

L. HEYNEMANN.

San Francisco, Cal.

Efficiency of Preparedness in Business

To the Editor of Metallurgical & Chemical Engineering:

SIR:—I was much interested to read the editorial in your issue of Nov. 15 on the process of inception in invention.

A month ago I spoke before the Efficiency Society in New York on the inception of business and engineering ideas in a lecture on "Efficiency of Preparedness in Business." This lecture, which follows, may be of interest to your readers.

The fact that a thing works proves that it is effective, but it may be far from efficient. The difficulty in measuring efficiency in preparedness increases steadily as we work back from performance and production to forecast and vision. I leave to others more competent the subject of economic laws governing all business ventures, and confine myself to inceptions not ruled out on this score.

Preparedness is a large topic, but to most business men it has a very limited significance. To some it means merely the enlargement of export business; to others a more or less organized readiness to take advantage of new opportunities at home; still others regard it as a call to greater efficiency in the tasks already in hand and in statistical analyses to that end. Some think of it as chiefly concerning campaigns of advertising, sales and distribution, and the anticipation of needs and styles, while others are wholly engrossed in producing commodities, and what they have not heard in the last few years about their shortcomings would hardly be worth listening to. The fact is that efficient preparedness is demanded nowadays at every stage in business, if we are to lead in the procession. It must be in evidence from the earliest thought regarding a promising idea or a generalization of value down to the elaborate formulation of specific plans to realize these ideas and to a host of precautions for launching them safely on the sea of experience and ensuring a successful voyage.

The efficient conducting of present business in its

many aspects is the matter upon which the Efficiency Society exercises most of its thought, but "preparedness" is essentially concerned with things more or less indefinite which are yet to arrive. I will, therefore, avoid covering the well-traveled road of "the art of getting things done," and dwell upon the qualities demanded for business "preparedness" in three relations, viz., *inception, organization and operation.*

I know of just three ways for attaining wisdom, and thereby efficiency and preparedness on anything, whether it be business or baseball, motors or morals. These are *thinking, imitation and experience.* Thinking is the finest way, imitation is the easiest way, and experience the most difficult way.

A preparedness attained solely by experience is apt to be laborious and long delayed. Reached by imitation alone it adds to our experience, but fails to develop self-reliance; whereas a wise provision attained by a well-disciplined mind concentrating on a problem is the best of all, for it is the earnest of more successes of the same kind.

Efficient preparedness in business is the result of the interplay of these three factors combined with the industry necessary to intensify them. Such preparedness, however, in the matter of inceptions cannot be always measured by the result of the project for many other elements enter into performance and enhance or nullify the original conception. It is for this reason that good ideas poorly supported are apt to be overlooked and that efficient support of a poor scheme is so often a thankless task. Proprietors are too little given to analyses of their failures, and bookkeeping rarely explains anything about poor inceptions.

INCEPTIONS

Consider first the nature of the mental processes that lead to the initiative and originality characteristic of preparedness. The thorough co-operation of the three wisdom factors I have named and the quality of the minds engaged are the sole factors conditioning the birth of new business ideas. Mental grasp and imaginative power exercised upon the real facts of the problem are paramount here.

Obviously if the inception of a policy or plan is insufficient, inaccurate, and, therefore, inefficient, it matters little what may be done later by good organization and operation to support it. The best thing that can happen to the many inefficient inceptions is that they should never see the light or that they should be submitted to the test of intelligent and fearless criticism.

Unfortunately many of them reach the rank and file in business with executive indorsement, if not also with executive origination, and are *not* open to challenge. Thereby hang not a few sad tales about rainbow chasing. Actual business occurrences show that lack of thought, lack of imitation and observation, and lack of knowledge of scientific and industrial principles are to be found in men who have inceptions of the highest importance in their control. Good business is the art of selecting probabilities and poor business is the result of taking chances on possibilities merely.

Sound concepts, visions, forecasts of coming events or needs, or estimates of conditions by leaders in finance, commerce and industry are fundamentals in business preparedness, and in my experience those concerns have been most successful and stable where the fewest things, external or internal, "just happened." Lack of preparedness is always rooted in lack of provision or inaccurate estimates, and we do not know how many bad guesses at the future are made on the average by our professional forecasters or the men at the mast-head of business. One authority says 10 per cent is

the minimum, and that 30 per cent more just escape failure. It is quite certain, however, that in our modern civilization, with its international business relations, acquaintance with other people and their conditions, is not widespread, and planning, preparedness and clear thinking are none too prominent. The gambler's chance in this land of promise and of quick recoveries is all too common, but its days are numbered.

We need in both our home and foreign business outlooks more statesman-like qualities, for we are destined, if we accept the nomination, to lead the world's markets. We are at present the great creditor nation; whether we shall remain so depends upon a strict attention to preparedness not yet in evidence. It is very important, therefore, to start right with the elementary ideas of projects, and many of our business inceptions fail right here, though, unfortunately, the failure is sometimes concealed from the onlooker until capital has been irretrievably wasted upon the project, and then various more obvious but secondary reasons are advanced for the collapse.

There have been no more striking instances of this than in the adventures of some of our own men of finance in the realm of industry. Their failure and surprise at being unable to juggle with matter and men after the skillful fashion of the world of figures and speculation has been instructive. Again and again financiers of the keenest intelligence and success in their own special spheres have been fooled, not through the operation of the law of average but by inceptions and projects inherently uneconomical and needing no wizard to discover this. For any efficient preparedness in such cases we look in vain. Apparently they could not resist the attractive terms either offered or possibly conceded for their capital and they swallowed the bait whole, with the reservation that any resulting burdens could be fastened on the backs of others. The first element in efficient business preparedness is to start right, trusting to no adventitious aid from capital or influence to attain that for which we have not laid secure foundations.

In the matter of the inception of great business ideas the lack of the trained mind in the adult is almost beyond remedy. But even trained minds will fail here if they lack imagination. So far as my experience goes, nearly every good idea in business, embodied finally in a project, arose from trained minds carrying thought past all verified phenomena and experiences into the realm of intuition. In other words, the step attained by what is really the scientific use of the imagination was a step beyond the last solid ground. Imagination played with and around ideas and ultimately flamed into consciousness of that which was yet to be proved. All the great originators testify to this, and our ordinary minds operate in the same way. It was thus that Newton took the stupendous leap from a falling apple to a falling moon, and it is a true saying that "science only gives us *hints* of what by a higher method we come to know."

But with our imagination among the stars, our feet must be firmly planted on the ground, for we are not dreaming here; we are consciously cerebrating, and so long as we think correctly we must think of things as they *are*. The state of mind within us must correspond to the state of things without us whenever a call comes for comparing them. Some people are intellectually dishonest, and in inceptions decline to see what they do not want to see. It is as if a man relished cheating himself at solitaire. In all preparedness, therefore, a passion for facts should rule and we should be willing to go far afield to get all relevant experiences. The mind also should be a nimble one for immediate

decisions may be demanded. But given a clear, clean, intellectual start the originator of business and industrial ideas should launch out boldly in mental speculation; open-minded, struggling against preconceptions of ideas and of people; ready to correct imperfect estimates of things and of character, and to welcome any new truth when it has proved its title, despite its impact upon cherished beliefs.

Such thinking and brooding over facts, always fortified by personal experience, keen observation and resourcefulness, is the secret of power and of efficiency in business preparedness. It gives a man the ability to acquire, to marshal, to master ideas and to forge from them a weapon to conquer men, or commerce, or adverse circumstance. Such subjects as the search for new markets, the stimulation of old ones, new products, improved merchandise, reduction of the present huge cost of distribution and selling, the influence of tariffs, the present trend of these in our own and foreign countries, the demands of the export customer, his banking needs, not to speak of the purely internal problems of a business, these and a score of others should keep our inception departments working overtime at this momentous epoch in our commercial career when the shrewdest analysis is necessary to forecast the economic result to each business of the present waste of men and capital abroad.

I have devoted most time to inceptions, to the preparedness which sets to work, for fruitful ideas, the right quality of mind, with the appropriate experience, upon the external and internal problems of the near and distant future of a business. This is not arm-chair work by any means. It may and often does call for travel and contact with all sorts and conditions of men. A few of our great corporations with international connections are highly efficient in their preparedness, but the average American concern does little to develop preparedness for foreign opportunities. Fortunately, our Department of Commerce is steadily increasing its consular service in this particular and improving its methods of circulating information, but the benefits will not be reaped by our commerce until we go after this trade in earnest and take great preliminary pains.

ORGANIZATION

I will deal very briefly with preparedness in the later stages of business. What is the next stage in order of importance? System says one; capital says another; credits say others, and so forth. The second essential in my opinion is efficient *organization*. Here again the triple discipline of thinking, imitation, experience, must be brought to bear upon the issue. One of Kipling's characters explains the failure of a cherished project by saying, "Now I saw so clearly what things needed to be done that I forgot that things are only accomplished by means of *men*." He was a big man himself but he had failed to organize.

In these days organization is receiving much attention. It can never get too much, but I think a word of caution is needed. That organization is not necessarily best considered that is represented by the most imposing chart. It is quality not quantity that counts for most in the executive circle, and the wise selection of the brains of a business is all-important. Not only so, but the task is not done once for all. I do not mean by this that fussy interference every few months with a stabilized staff is desirable—that is simply evidence of incompetence higher up. But men change, or fail to develop; their characters deteriorate or we make a mistake in our early choice. Hence for preparedness we must revise from time to time our selections of the human factors in business, and always with the sincere

desire to take the square man out of the round hole and put him where he fits.

Preparedness calls for truer discrimination of suitability than at present and, at the initial stages, more use of the science of character-reading and of the psychology and physiology of business aptitudes in which notable progress has been made in the past five years. The employment department is coming into its own. Under competent administration it is no longer a mere laborer's registry. It classifies aptitudes competently, and even the higher salaried men are no longer engaged upon chance impressions of their personalities.

OPERATION

I close with a few words on preparedness in the operating departments of business, which present the largest field. The new leaven which has been fermenting in business in the last ten years has worked chiefly in industry. Management has been struggling from an art toward a science, and, while I do not think it has attained that goal, the machinery of management, namely, system, has been evolving rapidly. Whether too rapidly or too completely we will not inquire here. The question before us is what is the essence of preparedness in the operating department; in its mills and plants and stores; in sales and distribution of products and in the office, clerical and recording functions of all of these?

The new element in preparedness is the use of the "scientific method" in attacking problems. The scientific method, however, is not any particular system nor is it a tool that you can keep handy on the shelf for occasional use only. It is as old as Socrates and the dawn of science, but in its conscious application to business it is as new as to-day. It is essentially an attitude of the mind which influences our business conduct, plans and decisions, and causes us habitually to observe, describe, analyze and classify with accuracy the phenomena which recur in our daily round.

The result is that we apply these analyses and experiences to regulate later affairs and shape all our records so that they are interpretive and constructive. At the same time all this is confined solely to the problems where it is *economically justified*. Many men of outstanding ability in inception do all of these analyses by mind and memory, but in the operating departments we need store houses for facts and conveyors for our decisions, and the real question of system economy is, What kind and how many? It is the possession of adequate discrimination in this matter that distinguishes the mere statistician from the efficiency business planner and forecaster.

Finally let me refer to the great importance of preparedness in labor management. Do not attend to all else and give the human problem "absent treatment." More and more society in this favored land is becoming just "all-of-us," and the capitalist or executive who does not want to belong is quite unfitted for the new industrial age. When times are tranquil and relations are harmonious, get acquainted with your people and let them become acquainted with you. Let trust and confidence be sown and you will not reap distrust and suspicion. Do not let the sowers of good-will be accompanied by a brass band or attempt to hasten the capitulation of the doubter by paternalistic policies which he cannot appreciate. Some one in all our large plants and organizations should be charged with this sort of preparedness; the sensing of the inarticulate but none the less real misconceptions—often grotesque—grievances and trivial grudges which, massed in time in narrow minds, are formidable obstacles to progress. Every business must meet the impact of troubles of outside

as well as inside origin but, if you know your people and they know you, you will not have to wake up in surprise and chagrin at the number of things you felt comfortably sure of, which turn out to be *not so*.

Here, then, is the conclusion of the whole matter of business preparedness. It is simply the concentration on the inceptions in every department of the best minds we have and the provision for systematically widening and recording experience. Behind every method, every practice, every custom in business and society alike lies an idea or group of ideas—a theory—a reason. Hence, the only practical things in life are ideas; the only *practical* man, the man of ideas, the man who *knows*, not merely the man who *does*. Behind our individual practice, whether we are conscious of it or not, lies the theory and only he who knows it possesses the rule of the higher practice and can take the next step wisely.

It is thus, on the last analysis, to the man of sound theory and of efficient mentality we must ever look for preparedness at its best, for better ways of doing the world's work, for progress and efficiency.

JOHN CALDER.

Lexington, Mass.

Perkin Medal Award to Dr. Baekeland

The Perkin Medal Committee, consisting of representatives of the different chemical societies of this country, has awarded the Perkin medal for 1916 to Dr. L. H. Baekeland.

According to established custom the presentation of the Perkin medal to Dr. Baekeland will be made at the January meeting of the Society of Chemical Industry in joint session with the American Chemical Society and the American Electrochemical Society.

The University and the Chemical Industry

Mass. Tech. Night at Meeting of New York Section of American Chemical Society

At the meeting of the New York Section of the American Chemical Society on Friday, Dec. 10, in joint session with the American Electrochemical Society and the Society of Chemical Industry, the symposium on "The Universities and the Chemical Industry" was continued. This was Mass. Tech. night, while for the preceding meeting (see our issue of Dec. 1, p. 885) Columbia University had provided the speakers, and in his introductory remarks the chairman, Dr. T. B. Wagner, stated that in a third meeting later in the season representatives of the chemical industry would have the floor.

President Richard C. Maclaurin of the Massachusetts Institute of Technology was the first speaker. The Massachusetts Institute is a university in everything but name. The industries of this country will never rise to what they ought to be until they become imbued with the spirit of the university, the scientific spirit. On the other hand, the universities will never rise to their true level until they become permeated with the spirit of industries. The growth of the chemical industries is reflected by the fact that at Mass. Tech. the study of chemistry has grown three-fold in the last decade; to-day one-fifth of its total student body, or 350 students, take courses in chemistry or electrochemistry.

The function of the university is to help to organize industries on a scientific basis. Three essentials the university can give to the student: a knowledge of fundamentals in science, an appreciation of the methods of science and their application to industry, and the spirit of science, the spirit of research.

The real question is: Are the universities doing

enough? They are limited by the available funds. The salaries of the professors should be raised—if only to one-tenth of what they might expect to earn in the practice of their professions. To attract better students to the study of chemistry the prevalent opinion that chemists are poorly paid must be overcome. The professors should be in closer contact with the industries; in this respect we should take a leaf out of Germany's book. The professor of pure chemistry must not be overlooked. The problem of America is to organize all available knowledge. A lot is stored up in the professors of pure chemistry, and even in textbooks. Perhaps our greatest problem is not so much to break new ground, but to make use of what we have. Germany became rich in peace by believing in the obvious, by having faith in the obvious. This America has still to learn, to believe in the organization of science for the industry. The universities want to help. They are imbued with the desire of rendering service, if only the industries will say what they want.

Dr. Henry P. Talbot, professor of inorganic chemistry at Mass. Tech. was the next speaker. The Carnegie Foundations for the Advancement of Teaching has recently undertaken an exhaustive study of the present status of engineering education, and Prof. C. R. Mann has sent out many letters of inquiry to many members of engineering societies. From the replies received it appears that what is considered most vital for professional success, are such personal traits as character, personality, innate ability, perseverance, temperament, leadership, aims—for self or work. But these are exactly the factors over which the universities have the least influence. Then there are traits which are largely God-given but can be fostered by universities—integrity and honesty, tact, ability to co-operate, resourcefulness, power of expression, ability to understand and deal with men, and cultivation of engineering spirit. The university may and should catalyze the latent powers which Nature has bestowed (using due care to avoid negative catalysis, which is far more likely to occur in the educational than in the chemical field), but the university is practically unable to create such powers.

There still remains a serious criticism—that the graduates from our educational institutions fail to catch what may be termed the engineer's viewpoint, as applied to chemical industries. In the opinion of their employers they lack constructive imagination; they do not appreciate how diversified are the factors which enter into commercial operations nor the complexity of the human relationships and agencies involved; they have little business sense.

I can point out one particular in which it seems to me that our institutions are at fault: that they have not sufficiently required or even encouraged those of their staff who claim that they are fitting men for the industries to take adequate pains to acquaint themselves with the conditions under which those industries exist and prosper. It has been aptly said that the efficient teacher must have his knowledge in the "contagious form." It must be at least as true that the instructor who is capable of equipping his pupils to grapple with industrial problems in the broad sense, must have acquired the engineer's viewpoint, before he can impart it. I believe that we can only attain the best results when every instructor concerned with undergraduate courses has made such an acquisition, not merely one or two members of a staff whose particular business it happens to be to give courses labeled Industrial Chemistry or Chemical Engineering. The effect must be cumulative. . . . On the part of a teacher who has had some industrial experience, there is an increase of resourcefulness, especially in the matter of illustration of principles, which vitalizes his instruction. It surely need not commercialize his instruction; it does tend to enrich it and to give to the more academic phases of it, which must always be the backbone of the training, greater vitality. . . .

One of the most frequent criticisms of the young graduate relates to his inability to understand or make himself understood by other men; to his failures to co-operate with others or to direct the work of others, even though the latter are less intelligent than himself. It is quite possible that our schemes of instructions for the chemists and chemical engineers, as they have actually taken form, do tend toward more individualism, and less of concerted action than is true in the case of other engineering professions, where students are much more likely to work in squads. This matter deserves and is receiving some consideration.

Dr. Talbot thought it would be a great help if students could obtain even simple employment in manufacturing plants in summer. As to the instructors the universities should put a premium upon or, when practicable, demand of its instructing staff some sort of real contact with industrial processes. Even a round of visits among operating plants, of a fortnight's duration, is a wonderful education.

Undoubtedly the greatest service which the universities could render the industries in the training of young men would be to increase the proportion of large-minded, mature teachers. Unhappily, those entrusted with administrative duties realize that it is increasingly difficult (especially in chemistry to-day) to attract and hold such men (especially young men) in competition with the attractions in the technical field. This not alone because of the increased emolument which they offer; it is quite as much because of the opportunities for tangible achievement. It is, of course, too much to ask of the industries that they should refrain from securing the services of such men, but it seems very desirable to make an effort to devise some plan of co-operation which will, in a considerable number of cases, permit able men to serve the industries, without severing their connections with the educational institutions.

Dr. William H. Walker, professor of chemical engineering at Mass. Tech., followed. The university is not in that active co-operation with the industrial life of the country which makes for the greatest national efficiency and prosperity. In which respects have the industries failed to take their full part in meeting this demand for more efficient co-operation? The first criticism of the industries is their failure to make known to the university what their troubles and their problems are. This proposition is simple in its statement, but fundamental in its importance and far-reaching in its results.

One reason for this condition of things is that the industries have too little faith in the university as a source of help. A manufacturer consults the professional man and soon discovers that he does not know the details of his plant or his process or his product. He at once concludes that however able and learned the professor may be, he is too ignorant of the subject in hand to be of service. Here is where the manufacturer goes wrong. It is not only unnecessary, but as a rule undesirable, that the university professor should know the detail of the problem which is so familiar to the manufacturer. Co-operation signifies the combined striving of two people toward the same end. When the manufacturer contributes the practical details of the problem, and to this the university man adds a broad knowledge of the facts and principles of science, with a training and experience in the application of these facts and principles, there is created a team which will produce results to satisfy the most exacting. This is what co-operation means; and it is this combination of science and industry that has made Germany the power she is to-day.

A second reason is, that there is a lack of frankness and a want of confidence on the part of the industries when dealing with the University man, which so far as I know is not merited by him, and which too often makes efficient co-operation impossible. The university man . . . can aid efficiently and intelligently only when he is in possession of all the facts. If the scientist is not worthy of being entrusted with the whole story, he is a dangerous man to be in possession of any part of it. Nothing is more discouraging to the university man than to expend a lot of time and energy on a problem only to later find that he was kept in ignorance of conditions which made the results of his earlier work useless. If the scientific man cannot be a confidential man, his usefulness to the manufacturer has vanished.

The next matter in which the industries are at fault, is in not assuming a more liberal attitude toward the publication of the results of research work done for the industries

by the universities and their graduates. There is a feeling on the part of the president or manager of the company that if the university man be generously reimbursed for his time and trouble that he should be satisfied. No scientific man should be, and few scientific men are, satisfied with a purely monetary return for their labor. They appreciate that they are under an obligation to contribute their share toward the development of their science. . . . In every piece of research work there are results which could be published in a perfectly impersonal way, so to speak, that would enrich science, and do the industries no harm. . . .

The unfortunate use of the words "pure" and "applied" research has led to the almost unconscious assumption that the only motive behind pure research is to enrich science, while the sole motive actuating applied research is to enrich the investigator or the organization financing the investigation. This latter assumption is unwarranted. Because an investigation is to be utilized, is no reason why the work should not be done with that thoroughness and accuracy which produces the best of scientific results. . . . Consider the splendid research carried on by Whitney and Langmuir on the behavior of gases at very high temperatures. It is immaterial whether you consider this the finest type of pure research from which the commercially valuable gas-filled tungsten lamp resulted, or an exceedingly profitable piece of industrial research in which purely scientific results of great value and interest were obtained, and given to the world. The goal toward which we should strive is to conduct our investigations so that the only distinction which can be drawn between pure and applied research, is the interval which will probably elapse between the time when the results are obtained, and the time when they become of service to the community.

A fundamental difficulty which presents itself when we in America attempt to introduce science into industry as compared to the ease with which the same thing is done in Germany, is occasioned by the absence of the equivalent of the German "technical director." . . . The average directing head of an American organization may have all the training necessary to be the son of the owner, or the representative of the majority stockholders, or of the banking syndicate which financed the industry; but he lacks the training which enables him to appreciate the atmosphere which must surround research work or in fact scientific work of any kind if it is to be successful. The infinite patience of the German investigator is made possible and profitable only by a corresponding infinite appreciation and sympathy on the part of the managing director. We may talk until the crack of doom about the miraculous results of Germany; but so long as we continue to draw the technical directors of our industries, the men on whom decision as to development work depends, from the purely commercial side of the organization rather than from those men with a scientific training, just so long shall we continue, notwithstanding our great natural resources, to cry for a protective tariff, more favorable patent laws, and other wholly temporary and superficial aids.

Finally we come to that factor in which the industries are most woefully lacking, and to remedy which the university has done almost nothing, namely the absence of intelligent foremen. . . . While science forced into an organization from on top is most helpful, some science introduced at the bottom is also necessary. . . . Here is a golden opportunity for the university, using this term always in the broad sense already stated, and the industries, to co-operate as they have never done before. All through the long summer the industrial and chemical engineering laboratories of our large institutions are empty. Why should this expensive equipment be idle when there are so many anxious to use it? Time does not suffice to outline in detail a plan which we are developing at the Institute of Technology, to present to young foremen and superintendents the principles of physics and chemistry on which their chosen industry depends. We propose to assemble each summer in our chemical engineering laboratory apparatus designed to present one specific industry. We shall invite that industry to send to us their more promising and ambitious men, in order that they may learn the scientific principles upon which the control of the raw materials, the process and the product depend. There are grave difficulties in such a plan, I admit, but co-operation can solve them. The objection met most frequently is that the industries cannot spare a good foreman for so long a time as six weeks. I can only say, that the foreman does not exist who may not at any time be taken out of the factory for six weeks by pneumonia, or typhoid fever, and yet the factory would not stop, nor the foreman lose his position. No more promising field exists, nor one fraught with greater possibilities for the industrial progress of this country than the opportunity which this

problem presents for co-operation between the university and industry. The foremen are anxious to learn; the industries are anxious to have them know; the universities are anxious to teach: Let's get together.

Mr. Arthur D. Little, in closest touch with the industry as president of Arthur D. Little, Inc., and in equally close touch with the Mass. Tech. as a member of its Corporation, made the final speech of the symposium. He pointed out that the part which science plays in furthering industrial development is not sufficiently appreciated by bankers, capitalists, men of affairs, and directors of industry, nor by superintendents, foremen, work people and the public generally. The directors of industry frequently ignore science. The attitude of superintendents and foremen and industrial workers generally to the innovation and betterments proposed by science is far too commonly one of militant scepticism or hostile suspicion.

Now all these individuals are social units who, with many other interdependent and mutually reacting units, together constitute the public at large. One may therefore fairly claim that our universities, great technical schools and colleges cannot serve business better than by directing some considerable part of their immense collective resources and influence toward creating in the public mind the mental atmosphere in which only business can truly flourish.

The first great necessity of business, as it seems to me, is a wiser, less recklessly extravagant and more generally efficient government of nation, State and municipality, and, as a corollary, a higher respect for law in the community. The second urgent need of business is that of establishing in the public mind as axioms the broad facts and principles without such general acceptance of which business cannot be carried on at high efficiency anywhere.

Business for example suffers much from the notion prevalent in certain quarters that all wealth is produced by labor and none by brains. It is likely to suffer still more from the idea that the productive capacity of all should be limited by that of the least capable. So, again, is business hampered by the general ignorance of workers and superintendents as to what research is and what it can do for them.

The University of Wisconsin has done much to raise the standard of government in Wisconsin. Other universities everywhere are doing something, but could do much more, to combat the influence of pernicious ideas and enlighten obstructive ignorance.

To those of us who come in contact in considerable numbers with recent university graduates, one of the most shocking defects in the educational system of which they are the product is found in the pitiful lack of decision exhibited by the majority of these young men concerning the work and place in the world for which they are best fitted. One gains the impression that all too often the educational processes to which they have been subjected have been akin to the Strassburg process of stuffing by which geese are fattened. Or, they have been taught as Dr. Johnson said books were made, as an apothecary puts up a prescription, by pouring a little from many large bottles into one small bottle. It is not surprising that both the Strassburg process and that of the apothecary should have failed to draw out and develop the native capacities and latent possibilities of the student or that they should leave him with no well defined directive impulse.

Such a state of affairs is happily not true of our technical schools and it ought not to be true of our universities.

Those of us who have received the benefit of any sort of scientific training are constantly amazed at the ignorance of cultivated men and women, business men and work people, regarding the simplest phenomena by which they are surrounded. To a deplorably large proportion of the community the striking of a match, the lighting of a fire, the freezing of water, the fall of snow, the sending of a telegram or a talk by telephone, the operation of a steam engine, or the turning on of an electric light, involve mysteries as far beyond their range of thought as the cause of gravitation or the rotation of the nebulae.

Since business involves at every point contact with natural phenomena and since the proper understanding of these phenomena, or at least some realization of what underlies them, often determines the measure of success attained in business, the university might well establish a compulsory elementary course in general science. This should be designed to give the student at least a rudimentary knowledge of the field covered by the different sciences, the relation of their subject matter to natural

phenomena in the affairs of everyday life and those of business, the interdependence of the sciences, and, above all, a clear idea of the scientific method. Such a course could not fail to prove an immense stimulus to any intelligent mind. It would open out new horizons for thought and put an altogether different and more interesting aspect on the world in which we live and in which we must do business.

The business man seldom has at his disposal any more potentially efficient tool than the English language, but in his hands it is a tool which is often rusty and very seldom so keen and highly tempered as to be capable of rendering its highest service. The fault for this is largely with our universities, and the remedy, so far at least as their own students are concerned, is in their hands. Our great institutions of learning are every day disgraced by the inability of their recent graduates to make a concise and convincing oral statement of a series of facts, to prepare a well organized and adequate report, or even to write a graceful and informing letter.

There is finally a very definite field in which our smaller colleges can do much for business, and that is by offering specialized courses in the science and technology of particular industries which are highly developed in their locality. Ohio State University, for example, has for years specialized in this way regarding coal, and the University of Maine is now instituting courses in paper making. Other colleges and universities are favorably situated as to particular industries, in such numbers and with such variety of opportunity that, were these opportunities utilized in even moderate measure, the young man who desired to prepare himself for any line of industrial activity would have within his reach the means of realizing his ambition.

The result would be the constant accession to the ranks of business of annual quotas of young men not blindly groping into an unknown world like the modern graduate, but advancing eagerly with open eyes toward responsibilities which they know that they can meet.

This closed the symposium on "university and industry." Dr. L. H. Baekeland then presented his address on the Naval Consulting Board which is printed in full on page 943 of this issue. Dr. W. R. Whitney, also a member of the Naval Consulting Board, added a few humorous remarks, and the meeting adjourned.

The Iron and Steel Market

Prices on Lake Superior iron ore for the coming season were announced Nov. 8 by the Cleveland ore interests. The schedule will probably be as follows: Old range Bessemer, \$4.45; old range non-Bessemer, \$3.70; Mesabi Bessemer, \$4.20; Mesabi non-Bessemer, \$3.55, per gross ton on Lake Erie dock. The standard or base ore contains 55 per cent iron in the case of Bessemer and 51.50 per cent iron in the case of non-Bessemer, natural state. For ores whose iron content is near that of the base settlement is made on a straight unit basis, in proportion to the actual iron content, but in case of considerable departure the system of computation is more complicated. In Bessemer there are phosphorus premiums and penalties, in accordance with departures from a base of 0.045 per cent phosphorus content. Generally speaking, the 1916 schedule is about 75 cents a ton above the prices of 1912, 1914 and 1915, the lowest since 1904, and 50 cents under the prices of 1907 and 1910, the highest since 1900. The entire advance of 75 cents for 1916 does not go to the ore producer, as vessel rates were recently established at 10 cents advance over the rate for 1915, and further advances are likely. The Steel Corporation set the 10-cent advance recently by chartering vessels to the extent of a 10,000,000-ton movement, and since then owners of vessels have been chary about contracting at all.

Shipments of ore down the lakes in the season just closed total 46,318,804 tons, against 32,021,900 tons in 1914 and 49,070,478 tons in 1913, the banner year. Besides the lake shipments about 750,000 tons of ore is usually moved by all-rail routes. The forecast is that 60,000,000 tons or more will be required next year, but doubt is expressed whether as much ore can be carried

by the vessels. There would be no difficulty about mining the tonnage, in all probability.

The steel market has come almost to a standstill as to the booking of strictly new orders, for a heavy tonnage continues to pour into the mills in the form of specifications on existing contracts. The mills will accept specific orders, at a price, for almost any delivery they can make, when it appears that the steel will be needed for a definite purpose, but the deliveries are such that buyers are but little interested. What many buyers would like to secure is protection for third quarter and later deliveries by open contracts, subject to later specification, but the mills are indisposed to commit themselves so far ahead.

The steel market is likely to be quiet, generally speaking, for two or three months while the mills straighten out their obligations. So heavy has been the specifying, and so rapidly have obligations piled up on mill books, that a great many arrangements have to be made with buyers. Often it occurs that a buyer will request that an earlier delivery be made on a specification filed later than another.

Emphasis should be laid upon the fact that the war demand is now a relatively minor factor in steel trade activity, domestic demand having increased so sharply in recent months. An illuminating comparison can be made. The last period of full activity in the steel industry extended from early in 1912 until late in 1913. The outputs in the calendar year 1913 may be taken as representing about 90 per cent as great a tonnage as would have been produced if the activity of the first nine months had been continued throughout the year. Dividing the outputs reported for 1913 by this factor we have: Pig iron, 34,500,000 tons; steel ingots, 33,600,000 tons; steel castings, 1,100,000 tons; finished rolled steel, 25,500,000 tons; finished rolled iron, 1,850,000 tons. Exports of steel products in 1913 amounted to about 2,300,000 tons. At the present time production is at the following estimated rates: Pig iron, 38,000,000 tons; steel ingots, 38,000,000 tons; steel castings, 1,000,000 tons; finished rolled steel, 28,000,000 tons, finished rolled iron, 1,500,000 tons. Direct and indirect exports probably represent about 7,000,000 tons of rolled steel, and more likely less than more than this quantity. Thus during the active portion of 1913 finished steel appears to have been delivered to the domestic trade at the rate of about 23,200,000 tons, while at present the rate seems to be about 21,000,000 tons, perhaps somewhat more. In most directions the domestic demand is much heavier than in 1913, for in 1913 there was more than 3,000,000 tons of rails produced for use in the United States, while the present production of rails is extremely light. There was also much more structural material consumed than is being consumed at present. Deducting for these two items, the domestic demand remaining appears to exceed quite materially that of 1913, the heaviest domestic demand that had been experienced up to this movement. The alignment is one that has been established but recently, and it is one that is perhaps not universally recognized even now.

Pig Iron

Pig iron has been advancing fully as rapidly since Dec. 1 as it did during November, the rate then, averaging various grades in the different markets, being between 35 and 40 cents per ton per week. The pig iron market has shown a very interesting reversal in its conduct as to prices. During the first six months of the year prices did not advance, although demand continually increased. Idle furnaces blew in from time to time and forestalled advances. In July, August and September demand increased further and moderate price ad-

vances occurred. In the past thirty days there has been little increase in the rate of consumption, and the tonnage demand in the market has been relatively light, yet prices have advanced very sharply, and evidently because the limit of productive capacity has been reached or closely approached. It is not demand alone, but the relation between demand and supply, that makes prices. The most spectacular performance has been by Bessemer pig iron in the valleys, which was quoted at \$17.50 to \$18, valley, in our last report, in the closing days of November. Early this month sales of 3500 tons were reported at \$18, fixing the market at that as minimum, but within a few days sales of 1100 tons were made at \$18.50, followed by sales of about 1500 tons at \$19. There may have been other sales, but if so the trade at large did not hear of them. Never before had Bessemer thus advanced on such an extremely light turnover. We quote: No. 2 foundry iron, delivered Philadelphia, \$18.25 to \$18.75; f.o.b. furnace, Buffalo, \$17.50 to \$18; delivered Cleveland, \$18.30; f.o.b. furnace, Chicago, \$18 to \$18.25; f.o.b. Birmingham, \$14 to \$14.50; at valley furnaces, 95 cents higher delivered Pittsburgh; Bessemer, \$19 to \$20; basic, \$17.50 to \$18; No. 2 foundry and malleable, \$18 to \$18.50, and gray forge, \$17.50 to \$18.

Steel

There is no regular open market for billets and sheet bars. The mills are very short of steel and prefer to take care of their regular finished steel trade together with their regular billet and sheet bar customers, leaving nothing to be offered in the open market for such deliveries as the mills would care to consider. Based partly upon private settlements in the trade the market is regarded as nominally quotable at about \$30 for Bessemer billets and sheet bars and about \$31 for open-hearth, f.o.b. maker's mill, Pittsburgh or Youngstown. Forging billets are quoted at about \$52, with a small turnover, and rods at about \$40.

Finished Steel

Prices of some of the steel products have become largely nominal. In bars, plates and shapes the large mills have a minimum of 1.70 cents, which they seem about to advance to 1.80 cents, for shipment at mill convenience, no early delivery being possible, while the smaller mills, able to make earlier deliveries, are securing premiums.

Prices quoted are f.o.b. Pittsburgh unless otherwise noted:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.70 cents to 2.10 cents, base.

Shapes, 1.70 cents to 1.80 cents.

Steel bars and bands, 1.70 cents to 1.90 cents base; steel hoops, 1.90 cents, base.

Iron bars, 1.859 cents to 1.959 cents, Philadelphia; 1.60 cents to 1.70 cents, Chicago; 1.85 cents to 1.90 cents, Pittsburgh.

Plain wire, 1.85 cents, base; wire nails, \$2 per keg, base; galvanized wire, 2.55 cents; painted barb wire, 2.15 cents; galvanized barb wire, 2.85 cents.

Sheets, blue annealed, 10 gage, 2.25 cents; black, 28 gage, 2.50 cents to 2.70 cents; galvanized, 28 gage, 4.75 cents to 5.00 cents; painted corrugated, 28 gage, 2.70 cents to 2.90 cents; galvanized corrugated, 28 gage, 4.80 cents to 5.05 cents.

Tin plate, \$3.60 for 100-lb. cokes.

Steel pipe, $\frac{3}{4}$ to 3-in., black, 78 per cent off list; galvanized, 73½ per cent off list.

Boiler tubes (less than carloads), 68 per cent off list.

Structural rivets, 2.50 cents; boiler rivets, 2.60 cents.

The Naval Consulting Board of the United States*

BY DR. L. H. BAEKELAND
Member of the Board

Modern war, whether it be for robbing, plundering and subjugating other nations, or for legitimate self-defense, has become primarily dependent upon exact knowledge, good scientific engineering, and to a large extent, applied chemistry.

Napoleon used to say that the Lord was on the side of the armies with the biggest artillery and the best ammunition; if this seemed true in his time, it sounds almost like an axiom to-day, when physical training, personal valor, bravery, or courage, appear to count for little if efficient technical equipment, based on sound scientific knowledge, is lacking.

Germany, with her enormous and well-drilled army, with her 42-centimeter guns, and other formidable equipment, would be hopelessly paralyzed did she not find in modern chemical processes of synthetic nitric acid from the air, the source of supply of this indispensable chemical. How otherwise, could she manufacture smokeless powder and explosives, since England succeeded in shutting her off from the general source of supply of nitrates from Chili?

THE NAVAL CONSULTING BOARD

Secretary Daniels seemed to be imbued with these facts, when by organizing the Naval Consulting Board of the United States, he desired to give to our Navy the benefit of the scientific and technical talent of this country.

Since then his example has been followed by the French Republic, who in her hour of danger, has organized a similar civilian board and has even raised it to the dignity of a ministry: "Le Ministère des Inventions."

Great Britain also has enlisted the services of a board of civilian scientists and technologists for her present war operations.

As to Germany, we know that long ago she has abundantly availed herself in her war plans of the advice and co-operation of her scientists, inventors and engineers.

Although general information about the Naval Consulting Board has been more or less available through the daily press, there seems to be a very hazy conception in the mind of the public as to its work and plans. Unfortunately, some published criticisms, emanating mostly from persons who neither seem to have the desire nor the tact to first obtain correct information, have caused a very misleading interpretation of the work of this board.

A BOARD WITHOUT "POLITICS"

To those whose limits of imagination do not go beyond petty political considerations, it may be well to point out that in the formation of this board, politics has not had even the most remote influence. Secretary Daniels appointed America's best known inventor, Edison, as chairman, and by the latter's advice, applied afterward to different engineering and scientific societies of the United States, so that each of them should designate two representatives best qualified to serve on the board, through which our Secretary of the Navy would try, as he expressed it, "to mobilize the inventors and engineering talent of the country in the service of the United States."

Until now, Mr. Daniels does not know whether there are any democrats, republicans or progressives on this board—nor does he care to know. He relieved himself of the responsibility of selecting the members of this board by putting the matter up to the representative engineering societies of the United States. If any of those societies did not make the best possible selection, they alone should bear the blame. In the meantime, it matters little as long as the majority of the board are men of such ability and personality that they cannot fail to impress their attitude and talent upon the work of the board.

IS THE BOARD TOO CUMBERSOME?

At first it seemed as if a board of twenty-two men was to be much hampered by cumbersomeness and by long deliberations; but this fear vanished after our first meetings. If any member felt inclined to use unnecessary oratory or rhetoric, he soon changed his mind after he noticed how the other members displayed mutual respect for each other's valuable time, how discussions of secondary importance were eliminated, and how this board proceeded with unusual directness toward matters of immediate importance.

THE TRIP ON THE MAYFLOWER

When the announcement was made that on the first day of our meetings we were to board the yacht of the President to proceed to the Indian Head Proving Ground, some of us were inclined to think that formalities and social affairs might interfere with the efficient distribution of our time. But this idea also was soon dispelled, as during this entire trip, the time was taken up with the discussion of subjects directly related to our work, while becoming acquainted with the other members of the Naval Consulting Board, as well as with the chiefs of the different departments of the Navy.

So little time was given to formalities that even a regular lunch was dispensed with, beyond the distribution of a few sandwiches, while discussing various matters. Our visit to Indian Head gave us an excellent opportunity to get some direct practical information upon matters of ordnance and ammunition.

We landed back in Washington after dark, but at half-past eight that same evening, we were to continue our meeting at Secretary Daniels' office. Although this left us scarcely a few minutes to swallow some supper, none of the members of the board failed to appear at the appointed time.

A JOINT MEETING WITH THE CHIEFS OF THE NAVY

It is not generally known that the Navy had, in itself, an advisory board which is made up as follows: Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy; Rear-Admiral W. S. Benson, Chief of Naval Operations; Rear-Admiral Victor Blue, Chief of Bureau of Navigation; Rear-Admiral Joseph Strauss, Chief of Bureau of Ordnance; Rear-Admiral R. S. Griffin, Chief of Bureau of Steam Engineering; Chief Constructor D. W. Taylor, Chief of Bureau of Construction and Repair; Civil Engineer H. R. Stanford, Chief of Bureau of Yards and Docks; Paymaster-General Samuel McGowan, Chief of Bureau of Supplies and Accounts; Surgeon-General W. C. Braisted, Chief of Bureau of Medicine and Surgery; Major-General George Barnett, Commandant of the Marine Corps, and Captain Ridley McLean, Judge-Advocate-General of the Navy.

All of us were impressed with the concise and business-like way in which each one of these gentlemen described his various responsibilities and presented the details of the subjects on which he desired the advice and assistance of the members of our board.

*An address made at the joint meeting of the New York Sections of American Chemical Society, American Electrochemical Society, and Society of Chemical Industry, Dec. 10, 1915.

Not only did they give us the convincing impression that they were sincerely glad to discuss their problems with us, but in doing so, they made us forget that they were the chief officers of the Navy; they appeared to us like so many engineering or business men who in a simple and direct way, wanted to discuss questions on which they felt their grave responsibilities. To anyone who is acquainted with all the pose and overbearing attitude of European military caste, and who might fear that this nation might bear the incubus of militarism, direct acquaintance with men like these would soon dispel this apprehension.

Nor did we see, anywhere among them, nor at the Army and Navy Club, nor at the Department of the Navy, as much as one single uniform, except, of course, on board the Mayflower, where the yacht's officers and crew were in uniform.

Notwithstanding the fact that no time was lost for unnecessary purposes, it was after midnight when the first day's meeting adjourned.

NO TIME GIVEN TO UNNECESSARY DISCUSSION

Early next morning we met again, this time at the library of the Navy, and then and there the board was organized for its future work. Here again, no time was spent upon side matters; everything was transacted in a practical direct way. For instance, when the rules of procedure for further meetings had to be discussed, a sub-committee was immediately organized with instructions to leave the room and report "not later than thirty minutes," so as not to impede other deliberations which were going on; the result was that when at noon we gathered for lunch, all questions of organization and subcommittees had been discussed, sifted and settled until future conditions may make it desirable to introduce any needed changes.

But even at lunch, the business meeting went on, and some of us had to interrupt our lunch, and go to a next room to deliberate further in a subcommittee, until a report could be submitted on some matters relating to this particular committee. So when at the end of this second day, the Naval Consulting Board adjourned, a good deal of work had been disposed of.

Shortly afterward another meeting was held in New York, where the organization of the subcommittees was completed, and where the different chairmen of the subcommittees were appointed.

A BOARD THAT RECEIVES NO PAY AND PROVIDES FOR ALL ITS OWN EXPENSES

For those who are accustomed to consider the United States Government as a big "milking cow" for salaries and remunerations, it may be of interest to know that no member of the Naval Consulting Board draws any salary, nor gets any remuneration from the Government.

We all pay our own traveling and hotel expenses and each member feels that if he can give his time, free of charge, to the Government, he can still better afford to pay his own expenses.

This program is carried out so scrupulously that even the cash for the purchase of stationery and printing is furnished by the members of the board, who are monthly assessed among themselves.

A "SHORT-CUT" BETWEEN THE NAVY AND THE INVENTORS OF THE COUNTRY

The general opinion of the members of the board is that its scope of usefulness can best be fulfilled by acting as a "go-between" or a "short-cut" to information between the heads of departments of the Navy, and any individual member of the different societies they represent. This carries into practice the idea of "mobilization of inventors and engineering talent" of Mr. Daniels.

The board mainly puts its services at the disposal of the chief officers of the Navy, as fast as the latter feel the necessity of co-operation or advice.

For instance, a subject relating to improvements in the manufacture or the composition of a certain explosive, would be referred to the subcommittee on chemistry and physics, as well as to the subcommittee on ordnance and explosives; the matter is discussed in these two committees and the members of these two committees decide whom to select among their fellow members of the chemical or engineering societies who are best qualified to help them in this task, and who, at the same time, are willing to co-operate without any other compensation than the feeling that they are working for the good and the security of our republic.

It is obvious that in handling all these matters, tact and discretion are just as indispensable qualifications as talent or knowledge, and this involves quite some responsibility for the members of the Consulting Board in selecting suitable collaborators.

As a matter of fact, several important pending problems are now actively before the subcommittees, and, notwithstanding the short time which has elapsed since the first meeting of the board, some of these questions are already in an encouraging phase toward successful solution.

THE SO-CALLED "FIVE-MILLION LABORATORY" OF THE NAVAL CONSULTING BOARD

The so-called "five-million laboratory," proposed by the Naval Consulting Board, has been the favorite subject of varied and picturesque criticisms which, as usual, originated more through lack of information than by ill-will.

Secretary Daniels requested each member to address to him his personal opinion on the advisability of the creation of a research laboratory where urgent technical matters relating to the needs of our Navy could be studied successfully.

At the second meeting a special committee was appointed to submit a joint report. On this committee were, besides Mr. Edison, four other members. One of the other members of the committee is a man who has earned a national reputation in organizing and developing one of our largest mechanical industries. The second member is at the head of perhaps the largest and best endowed scientific research institution of the world; another is the chief of one of the most successful chemical and physical industrial research laboratories of this country; the fifth has devoted much of his life to private chemical research.

VARIOUS OPINIONS OF HOW RESEARCH SHOULD BE CONDUCTED

It was interesting to follow how the five members grouped themselves in accordance with their own point of view, dictated by their daily scope of action: The chemical or purely scientific members of this committee agreed pretty well on the kind of research laboratory they had in view, and although their suggestions had been written independently without consulting each other, their general recommendations as to the organization, equipment, and needed expenditures were fairly similar and relatively modest.

But their recommendations were mainly limited to a chemical and physical laboratory; they did not include the study of elaborate mechanical and technical problems which go far beyond the questions which are usually dealt with in chemical and physical research laboratories.

The two other members, on the contrary, wanted to prepare thoroughly for engineering problems of imme-

diate importance, the solution of which seems indispensable if the money of the Navy is to be spent to best advantage.

They set forth, from their own direct experience, how very expensive such engineering experimental work is likely to be.

Edison, for instance, pointed out the millions he spent in developing some of the details of his inventions; another member identified with the automobile industry stated that one single automobile concern here in the United States had found it necessary to spend half a million dollars in one year for experiments and research.

The modest estimate for a merely chemical and physical laboratory was thus snowed under by the irrefutable evidence of the much larger needs for a suitable mechanical or engineering department.

Of course, it was argued that the Navy possesses already several experimental stations at its different Navy yards, and at the Torpedo Station in Newport, aside from the different testing laboratories for the materials used for ordnance or ammunition; that, furthermore, the excellent laboratory facilities of the Bureau of Standards are available.

The answer to this was that each and every one of the present institutions were more necessary than ever, but were totally insufficient; furthermore, the full co-operation of all of them is needed; all this in view of the fact that, at present, the Navy of this country is facing unusual responsibilities.

EXPERIMENTAL WORK CANNOT BE POSTPONED UNTIL IT IS TOO LATE

If it is deemed urgent to be prepared for defense, then this defense involves problems the solution of which cannot be deferred indefinitely. If something has to be done, it must be done immediately—not in five or ten years hence, when it may be too late.

In all of our present scientific research laboratories, time seems of relatively little or no account; problems which cannot be solved to-day can be solved to-morrow or in ten years or during the next generations; but this is not the case with the problems connected with the contemplated defense of our country; the solution of these problems cannot be postponed. They demand immediate action.

Nor is the condition of our Navy similar to that of an industrial concern that can afford to take chances with machinery or equipment which is not strictly up to date, and still show some commercial success. For instance, recent events have demonstrated that there is no use building the best and newest fortresses against an enemy who possesses guns strong enough to demolish everything in existence.

Nor is there any chance of success in using the very best artillery at anything like equal chances if your adversary can do his scouting and range-finding with aeroplanes provided with reliable engines, while your aeroplanes are equipped with motors which give out at unexpected moments.

In our clumsy war with weak Spain, we went into the field with black powder when all other nations, even Spain, were equipped with smokeless powder. Why? Because we had postponed too long studying the chemistry of the subject.

The fact is that if we require a Navy at all, our Navy cannot afford to use anything but the very best and most efficient means of defense. Not to possess the very best might put us in the same absurd condition as the wooden navies of the world were in after our civil war had established the supremacy of the iron-clad vessel.

RESEARCH MUST PREVENT THAT MONEY FOR DEFENSE SHOULD BE SPENT ON OBSOLETE OR INADEQUATE MEANS OF DEFENSE

The contemplated outlay for the Navy for the next five years, for new ships, aviation and reserve of munitions, amounts to about \$500,000,000. These tremendous expenditures of money, in order to be of real value, ought to be made as efficient as possible. All doubtful and inferior devices must be eliminated by direct experiment, by research and tests, *before* it is too late to remedy them.

This requires accelerated action; in fact, Mr. Edison's personal opinion was that research and laboratory work in this instance "should go on night and day without intermission" instead of the usual easy-going short-day plan followed in laboratories.

If one single automobile concern in the United States finds it to its advantage to spend in one year half a million dollars on testing, research, or experimentation, how much more important is the business of the United States Navy, where money not spent wisely is better not spent at all, because then at least we shall not have the illusion that we are equipped for defense, when we have merely lost our money on antiquated devices.

MILLIONS OF DAMAGE TO OUR FLEET ON ACCOUNT OF CORROSION OF CONDENSER TUBES

Without mentioning any spectacular problems of modern warfare, it might be stated that such a prosaic detail as the corrosion of condenser tubes of our warships, involves an annual damage of about \$2,000,000. If \$1,000,000 were spent on research on this problem alone, with the result of reducing the damage to one-half, the total outlay would be compensated in a few months' time, aside of the important fact that our fleet would be stronger because less of our ships would be unavailable for service.

It was brought out that there was little use in spending so many millions on flying machines as long as there was any doubt on the reliability of their engines, and until an absolutely well-tried and standardized engine had been developed. To accomplish this experimental work in a period of a few years would cost quite some money; but to do this rapidly, within a few months, before order is given to build these flying machines, requires enormous outlays of money, alongside of the indispensable engineering talent.

THE NAVY SHOULD FIND IT PROFITABLE TO SPEND AS MUCH FOR EXPERIMENTATION AS ANY PRIVATE INDUSTRIAL CONCERN

Another member brought out the fact that even conservative industrial enterprises found it necessary and profitable to spend at least 2 to 5 per cent of their sales on research and experiments. At this rate, the contemplated expenditure of \$500,000,000 in five years, would certainly warrant an expenditure of at least five million for research during that period.

Money for this purpose wisely used, ought to do so much good to the Navy as to increase its efficiency by the value of several battleships costing considerably more. Mr. Edison's arguments were particularly eloquent when he enumerated the enormous expenditures for research in his own laboratories.

In this discussion everybody seemed to be well in accord with the general idea that whatever expenditures were recommended, the contemplated work should be carried out under immediate supervision of the Navy; that this work should not be started all at once—full blast—but should be extended gradually, as fast as circumstances demand it.

In view of all this, two policies were open for obtain-

ing the necessary appropriations—the old time-honored trick of asking from Congress first an appropriation of a few thousand dollars, knowing very well that this would be insufficient, then after awhile ask an additional appropriation and keep on nagging and asking at various intervals.

But the members of the advisory board thought it a more honest policy to state the facts as they saw them and to confront the Secretary of the Navy with the probable maximum expenses for research and experimentation, commensurate to the five years' naval building program now under contemplation. The five-million dollar budget for experimental work to be expended during those five years, or about one million a year, may strike the uninitiated as needlessly large, although it is only about what some industrial enterprises have found necessary to spend on their own experimental work.

LET BLUNDERS BE COMMITTED IN A SMALL EXPERIMENTAL WAY INSTEAD OF ON A LARGE SCALE

But if the nation does not want to go to the expense of developing the latest and most efficient means for defense at the lowest cost by obtaining the necessary information through preliminary experiments, instead of committing mistakes on a large permanent scale; or if our country wants its Navy to keep on building its ships or other means of defense, as were good enough in the past, regardless of the fact that modern war requires the very latest and the most efficient available devices, then let us not be astonished if after incomparably more money has been spent for increased armaments, we find that we are loaded with means of defense which have become obsolete in the meantime and are good for the junkheap of antiquated equipment.

The foregoing is a brief résumé of various arguments which were submitted by some members of the board, and this is the first time that this discussion has been reported in public. Let us hope that its publication may help to dispel some of the ideas of the public which imagines that the board contemplates the immediate erection of a "\$5,000,000 laboratory building, where the members of the Naval Consulting Board can experiment to their hearts' content in company with long-haired inventors."

As Mr. Edison expressed it picturesquely: "The money should be spent not on buildings, but on a national junkshop," where means of defense can be tried out first, at relatively small cost so as to learn how to get the most and very best for the money, and so as to avoid making expensive and dangerous blunders on a wholesale scale.

ADMIRAL MELVILLE TWELVE YEARS AGO STRONGLY URGED EXPERIMENTAL WORK IN THE NAVY

More than twelve years ago one of the most distinguished officers of our Navy, Admiral George W. Melville, urged strenuously the necessity of naval engineering experiments; his well based arguments published in the *Proceedings of the Engineers' Club of Philadelphia* (Vol. XX, No. 3, July, 1903) brought out the fact that expenditures for experiments are the best means for avoiding expensive mistakes. What he said then, sounds even more convincing to-day.

The following quotations are taken from his paper:

"The hulls and machinery of these five battleships will cost approximately \$20,000,000. The armor, armament, and equipment will require an additional outlay of \$15,000,000; so that the actual cost of these battleships will probably be about \$7,000,000 each. The annual depreciation of each of these vessels from the time they are launched, taking into consideration wear and tear as well as loss in fighting value, will be at least 4 per cent of their actual cost. The expense attending the establishment of the proposed experimental station, including its operation for several years,

will thus be but little more than the annual loss resulting from corrosion, mishaps, and depreciation of military appliances of two of these floating fighting machines."

"The success of Germany can be accounted for only by recognizing the fact that study, reflection, and research must have been expended in the preparation of plans, in the building up and the organization of the shipyards, and in laying out and carrying on the work of construction. It was the high appreciation of the value of original investigation, coupled with experimental work, that has caused Germany to advance progressively and successfully."

"Where research had not been conducted, disappointment resulted from the construction of vessels which were either faulty in design, ill-suited for the purpose intended, or upon which an inferior quality of work had been expended."

"The problem as to whether or not in-turning screws are detrimental to maneuvering qualities would have been solved many years ago if the work planned by Mr. Isherwood had been continued. Our increased knowledge of the theory and practice of screw propulsion since the Isherwood experiments is due, however, almost wholly to the work of Froude, conducted for the British Admiralty. This is confirmatory evidence that such important and difficult work can only be undertaken by official or civilian experts who are able to call upon government resources for data and information. It requires government investigation to solve important problems relating to the powering of vessels, since valuable and far-reaching experiments upon this subject require the use of ships as well as the services of a large number of reliable and competent persons to collect the data requisite for the determination of absolute results."

"If it be true that the battleship of one generation is the junkheap of the next, then an economical race like the German is pursuing a wise policy in conducting experimental research and investigation in the direction of finding out how the weak links in the naval chain can be strengthened."

"Experience has shown that the German engineering laboratories are more than a good paying investment, for there is not an expert in that empire familiar with the work being done at these laboratories who does not believe that their destruction would be a greater national calamity to the navy and the nation than the loss of one of the battleships of the home squadron. The warship could be replaced in four years. It would take six years to rebuild and put in effective operation the complete installation for conducting experimental research that has been developed and perfected at the Charlottenburg and Dresden technical college."

"There is probably not an eminent naval or mechanical engineer in America or England who has given consideration to this question who is not also of the opinion that the establishment of a national experimental laboratory for naval purposes will vastly contribute to military strength. Probably the majority of these experts also believe that such an institution would eventually contribute more to actual naval strength than the building of a battleship. One does not need to possess vital imagination to realize that much is contributed to the fighting strength of a navy by carrying on research along engineering lines, and thus preventing the design, construction, and installation of appliances that are ill suited for the purposes intended."

"The cost of maintaining a battleship in commission will approximate \$1,000 per day, and warships have been tied up for weeks on account of the corrosion of a few hundred dollars' worth of boiler tubes. It will repay the nation for the cost of an experimental station if the staff of the laboratory will simply cause increased length of life of both boiler and condenser tubes."

Standardization of Metallurgical Units.—In the preliminary report of the Committee on Standardization of the Mining and Metallurgical Society of America (page 818 of our issue of Nov. 15) in the paragraph on "mesh of wire cloth" there is an error in regard to the relation of openings in the Tyler standard screen scale, to which the W. S. Tyler Company of Cleveland has kindly called our attention. The paragraph states: "This furnishes a standard screen scale in which the area of each successive opening in the scale is double that of the second preceding." It will be seen that with the ratio of the series the square root of 2, the areas of successive openings double the next preceding, instead of the second preceding."

The Cyanide Plant of the Baker Mines Co., Cornucopia, Oregon

BY ROBERT M. KEENEY

Formerly mill superintendent, Baker Mines Co.

The mill of the Baker Mines Co. was built in the summer of 1914 to treat the ore of the Last Chance mine, formerly owned by the Cornucopia Mines Co. The camp of Cornucopia is situated seventy-five miles northeast of Baker City, Ore., in Baker County. The nearest railroad station is Robinette on the Snake River branch of the Oregon Short Line Railroad. The roads are fair, and the camp is accessible by automobile in the summer, but all freight has to be hauled by wagon or sled. The winters are not cold, but there is a heavy snowfall with all the resulting obstacles to mining. All of the mines of the camp are in a snowslide country, making a careful choice of sites for buildings essential.

The district is very rough and precipitous with a considerable quantity of timber, being a part of the Minam national forest reserve. The rough character of the mountains is shown in Fig. 1 and Fig. 2. In Fig. 1 the mine is at the horizontal white streak at the extreme upper left hand corner of the picture. There are possibilities of numerous small high-head water-power developments in the neighborhood on Pine Creek and its branches, and at a greater distance on other creeks. Power could also be obtained from the Oxbow plant of the Oregon-Idaho Power Co. on the Snake River, thirty miles distant. The Baker Mines Co. mill is at an elevation of about 5325 ft., and the mine at 7000 ft.

The character of the ore milled is quite variable. Depending on the part of the mine from which it comes it may be oxidized, with some free gold, or a heavy sulphide ore. Most of the sulphide is pyrite, with smaller amounts of sphalerite, galena and chalcopryrite. The gangue is quartz. Pockets of telluride ore occur, and there is some copper present in an oxidized form. The battery heads assay from \$12 to \$16 per ton. The ratio



FIG. 1—MILL OF BAKER MINES CO., CORNUCOPIA, ORE.



FIG. 2—MINE BUILDINGS AND LOADING TERMINAL OF THE TRAMWAY

of gold to silver is variable, being from three parts of silver to one part of gold up to a five to one ratio.

The copper contents of the ore milled have varied from zero to 1.75 per cent, and have averaged for a month 0.21 per cent. At first the copper gave considerable trouble, due to fouling the solutions, but now chiefly causes a higher cyanide consumption and a higher zinc dust consumption. The gold extraction is not decreased much when the copper content increases, but the silver extraction is generally lower, probably due to more of the silver being in the form of a complex sulphide with copper.

Tramway

A Bleichert aerial tramway, erected by the Trenton Iron Works, conveys the ore from the lower tunnel of the mine to the mill. All supplies and miners go to the mine over the tramway except in summer when the mine is accessible by road. The upper terminal of the tramway is seen at the right in Fig. 2. Fig. 3 shows the lower terminal at the mill.

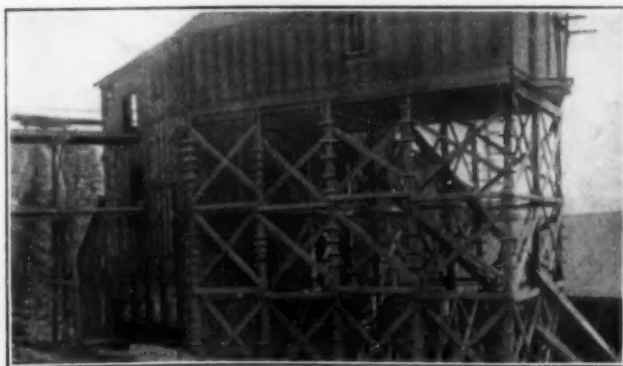


FIG. 3—DISCHARGE TERMINAL OF TRAMWAY AT THE MILL

When operated at full speed the tramway has a capacity of 15 tons of ore per hour. There are 24 buckets, each holding 6 cu. ft., or 625 lb. of ore. At full capacity the buckets run with the distance between them 625 ft., an interval of 75 sec., and speed of traction rope 500 ft. per minute. The length of the tramway is 5500 ft., with the loading terminal at 1675 ft. higher elevation than the discharge terminal. Between the two terminals there are two towers and a tension station. The span between the tension station and the discharge terminal at the mill is over 3200 ft. long, which is said to be the longest aerial tramway span in the United States. The track cable is of three sizes, $1\frac{3}{8}$ -in. diameter, $1\frac{1}{8}$ -in. diameter and $\frac{7}{8}$ -in. diameter. The tramway develops 21 hp. It was erected under very difficult conditions in a rough country, but even with the long span has given no trouble in operation, and after one winter appears to be as intended, immune from snowslides.

Mill Buildings

The buildings are of wood frame with corrugated iron roof and siding. Concrete foundations and retaining walls are used throughout. The mill buildings are shown in Figs. 1, 4 and 5. In Fig. 4 the main mill building and tramway terminal are at the left, and the precipitation building and store house on the right. The tramway discharges into the crusher over the ore bin at the head of the mill.

The mill is built on a hill side with a 15-deg. slope. The precipitation presses, barren solution tanks, melting furnaces and assay office are in a separate building about on the level of the ore bin.

Mill Equipment

In designing the mill several factors influenced the process and equipment, more than the idea of obtaining a very high recovery of values. The principal of these was the amount of power which could be developed locally without a considerable expenditure. If there had been sufficient power available without large outlay, it is probable that an all-sliming plant with tube mills would have been built instead of a sand and slime plant. On ore similar in a general way the Cornucopia Mines Co. obtains a 90 per cent extraction by the all-sliming process. The designers of the mill, John M. Baker and Paul W. Gaebelein, expected to eventually get an 85 per cent recovery, and a little better is now being obtained.

The mill equipment includes the following:

Grizzly— $1\frac{1}{2}$ -in. openings.

Crusher—No. 3 suspended type Austin gyratory crusher. Speed, 425 r.p.m., requiring 20 hp. Capacity, 10 to 20 tons per 24 hr. through $2\frac{1}{2}$ -in. ring.



FIG. 4—MILL BUILDINGS AND TRAMWAY TERMINAL

Battery Feeders—Four supported type Challenge feeders.

Stamp Mill—Twenty 850-lb. stamps. Stems, $3\frac{3}{8}$ in. in diameter by 14 ft. long. Two key tappets later replaced by three key tappets. Bossheads, $8\frac{3}{4}$ in. in diameter by 17 in. long. Chrome steel shoes, $8\frac{3}{4}$ in. in diameter by 9 in. high; weight, 165 to 170 lb. Cast-iron dies, $7\frac{3}{8}$ in. high by $8\frac{1}{2}$ in. diameter steel and iron fake bottoms 9 in. square by 3 in. thick. Four mortars: base, 4 ft. 6 in. by 2 ft. 3 in. Demarest steel guides with the stems $9\frac{1}{4}$ in. centers. Camshafts, $5\frac{3}{8}$ in. in diameter by 14 ft. long. Order of drop, 1-3-5-2-4. Drops per minute, 102. Height of discharge, 2 in. Drop, 7 in. Twenty-five mesh screens. Duty per stamp day, 3.4 tons. Power required, 40 hp.

Amalgamation Plates—Four silver-plated copper plates, 54 in. by 7 ft. 6 in. Grade, 2 in. per foot. Divided into two parts by strips to avoid hanging stamps when cleaning up or dressing the plates.

Dorr Classifier—Model C duplex Dorrr classifier with steel tank.

Leaching Tanks—Three fir tanks, 30 ft. in diameter by 10 ft. deep, with 3-in. staves. False bottoms covered by cocoa matting and canvas. Four 14-in. iron circular discharge gates in the bottom of each tank.

Sand Distributors—Three revolving-arm sand distributors.

Dorr Thickeners—Two thickeners in wooden tanks, 30 ft. in diameter and 10 ft. deep, with 3-in. staves. Arms revolving at $1/10$ r.p.m. One thickener in wooden tank, 20 ft. in diameter by 10 ft. deep, with 3-in. staves. Revolving at $1/5$ r.p.m.

Dorr Agitators—Three-inch wooden tanks, 20 ft. in diameter by 16 ft. deep, with 3-in. staves.

Portland Filter—One filter with drum, 14 ft. long by 9 ft. in diameter. Revolving at $1/6$ r.p.m.

Gould's Suction Vacuum Pump—One 14 in. by 10 in.

Gould's Triplex Pumps—Two pumps, 4 in. by 6 in.

Swaby Centrifugal Pumps—One 3-in., one 2-in.

Merrill Clarifying Press—Ten-frame, 36-in. sluicing clarifying press. Capacity, 210 tons clarified solution per 24 hr.

Gold Solution Tanks—Three fir tanks, 20 ft. in diameter by 10 ft. deep, with 3-in. staves.

Merrill Precipitation Presses—One 16-frame, 36-in. press and one 8-frame, 36-in. press. Combined capacity, 300 tons clarified solution per 24 hr.

Barren Solution Tanks—Two fir tanks, 20 ft. in diameter by 14 ft. deep, with 3-in. staves.

Merrill Zinc Dust Feeders and Emulsifiers—Two of each.

Furnaces—One 3-muffle drying furnace. Two Case oil-fired furnaces taking No. 135 crucible.

Water Wheel—One 6-ft. Pelton water wheel.

Air Compressor—Sullivan Class WG3, 14 in. by 12 in., single-stage belt-driven air compressor; 342 cu. ft.



FIG. 5—LOWER END OF MILL

free air per minute; 20 lb. per square inch pressure.
Requires 26 hp.

Power

The mill is belt-driven directly from a main line shaft which is belted to the Pelton wheel. The hydraulic installation consists of a pipe line 4000 ft. long, with 1036 ft. of wooden flume feeding the pipe from the east fork of Pine Creek. There is 1000 ft. of 10-in. 12-gage spiral riveted pipe with bolted joints, 1000 ft. of 10-in. 14-gage spiral riveted pipe with bolted joints, and 2000 ft. of 11-in. 16-gage spiral riveted pipe with slip joints. The actual head of water on the wheel is 537 ft., and the gage pressure at the wheel is 221 lb.

The maximum power developed is about 165 hp., but it takes only about 120 hp. to run the mill. After installation of the power plant it was found there was enough water available for development of as much more power, and another wheel is now being installed.

Operation

A flowsheet of the operation of the mill is shown in Fig. 6.

The ore is dumped from the tramway buckets on to a grizzly set with 1½-in. spaces, from which the under-size goes to the battery bin and the oversize to an Austin gyratory crusher, crushing to 1½ to 2½-in. size. Each battery of five stamps is fed from the bin by a Challenge feeder.

Crushing is done in a cyanide solution of 1.5 lb. KCN per ton strength and 1.0 lb. per ton CaO alkalinity. Lime is added in one battery. Ton cap screens of 25 mesh are used.

After passing over the plates the pulp, consisting of

about five tons of weak solution to one ton of ore, passes to a duplex Dorr classifier, where the sand and slime are separated. The sand is about 60 per cent of the total ore and the slime 40 per cent.

The sand, containing about 25 per cent moisture, is diluted with weak solution as it leaves the classifier, and is lifted by an air lift which discharges to the sand distributors at each leaching tank. The sand is leached with a solution containing 3 lb. per ton KCN and 1 lb. per ton CaO, called the strong solution. The first wash is with 1.5 lb. KCN solution from the weak storage tank, and the final wash is with water. Sodium cyanide is used to keep the solutions up to the required strength. The sand is discharged from the tanks by sluicing with high pressure water into a flume going to a tailings dam. Solutions percolating from the leaching tanks are turned into the weak or strong gold solution tanks as seems advisable and precipitated in Merrill presses. All of the strong solution is precipitated and most of the weak.

The slime leaves the Dorr classifier at a consistency of ten parts of liquid to one of solids, and flow by gravity into No. 1 Dorr thickener, a 30-ft. thickener. The overflow from No. 1 thickener goes to a 3-in. centrifugal pump, which pumps what solution is needed to the sand lift and the balance to the weak storage tank. The pulp from No. 1 thickener, of a 1 to 1 consistency, is lifted to a launder discharging into No. 1 agitator. In the agitator the pulp is diluted with strong solution to maintain a ratio of liquid to solids of 2.5 to 1. Sodium cyanide and lime are added to keep the agitator solution of 3 lb. KCN strength and 1 lb. CaO alkalinity.

The pulp passes from No. 1 agitator to No. 2 agitator and then to a 20-ft. Dorr thickener. Here dilution with strong solution is made 3.5 to 1. The overflow from this thickener passes into the feed box of a 2-in. centrifugal pump, which pumps through a Merrill clarifying press and discharges into the strong gold solution tank. In No. 2 thickener the pulp is thickened to 1.5 to 1, and raised by an air lift to No. 3 thickener, a 30-ft. thickener. In this thickener there is further dilution with strong solution to a ratio of 4 to 1. The overflow from the thickener is pumped through the clarifying press. The pulp is thickened to 1 to 1, and discharges by gravity into No. 3 Dorr agitator, which is used as a storage agitator, and at first was run without air agitation, simply mechanical agitation, but later the pulp was aerated as it appeared to increase extraction.

The pulp runs from the bottom of No. 3 agitator to the Portland filter. The slime from the filter discharges into the tailings flume, and the solution goes to the 3-in. centrifugal pump and enters the weak mill solution. The slime was at first washed at the filter with only one water spray, but now has several.

There is one strong gold solution tank and two weak gold solution tanks. One of the weak solution tanks is used chiefly to receive muddy solution from the leaching tanks when a tank is beginning to be filled, and when the clarifying press is being cleaned. The solution from this tank is precipitated only after it has settled well.

The strong solution containing about 2.5 lb. KCN and 1 lb. CaO per ton is pumped through a 16-frame Merrill precipitation press, which discharges barren solution to the strong storage tank, where it is strengthened with sodium cyanide to 3 lb. KCN per ton.

The solution from the weak gold solution tanks is pumped through an 8-frame Merrill press which discharges barren solution to the weak storage tank. No cyanide is added in this tank but enough is added in the weak gold tanks to keep the strength at 1.5 lb. KCN per ton before precipitation, as experience has shown that with much lower strength there is not a satisfactory

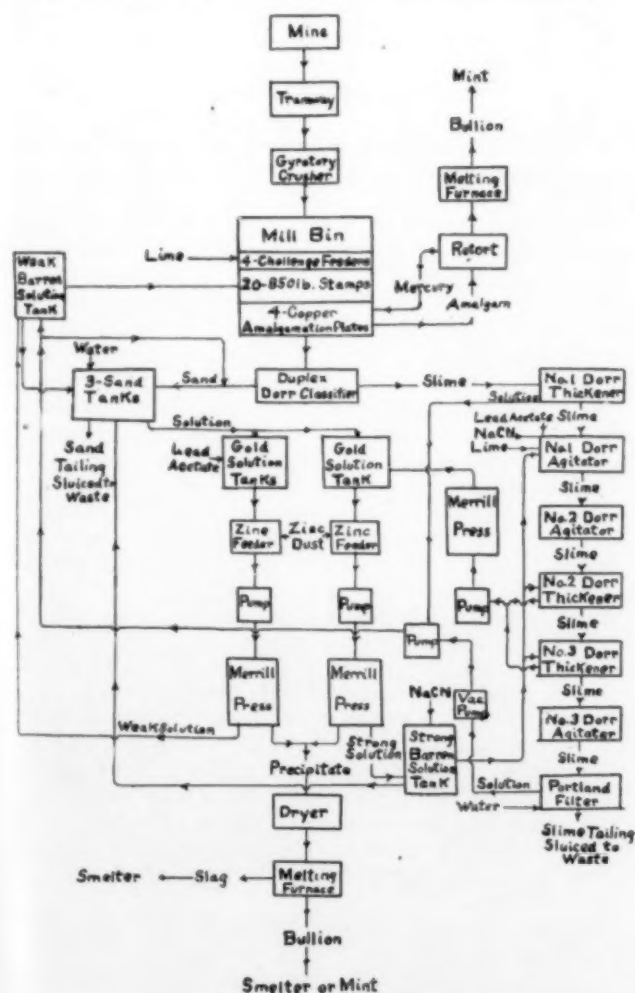


FIG. 6—FLOW-SHEET CYANIDE PLANT OF BAKER MINES CO.

precipitation. Some lead acetate is added in the weak gold tanks and also in No. 1 agitator.

The precipitation presses are cleaned up three times per month, and the precipitate dried in a muffle furnace. The dried precipitate is melted in Case oil-fired tilting furnaces, giving a low grade gold-silver-copper bullion as a product.

Amalgamation

Amalgamation is carried on in cyanide solution with poor efficiency of amalgamation, as is usually the case. While extraction by amalgamation is not high, amalgamation serves a useful purpose in that it catches the coarse gold not extracted by the cyanide solution. Even with amalgamation there is some loss of coarse gold as was shown by a concentration test on the tailings.

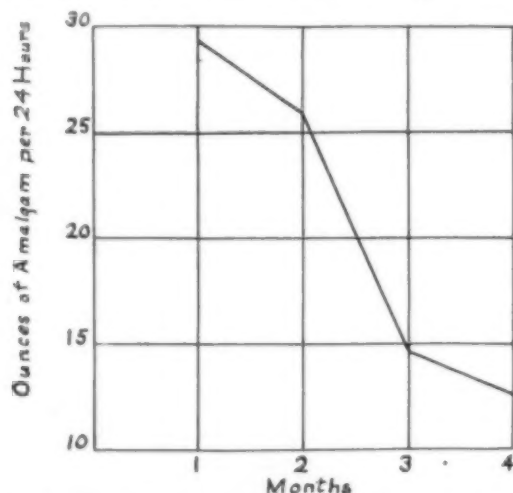


FIG. 7—EFFECT OF AMALGAMATION FOR FOUR MONTHS IN CYANIDE SOLUTION ON RECOVERY OF AMALGAM

During the first month and a half of operation of the mill oxidized ore was milled with the production of a considerable amount of gold by amalgamation. At the end of that period the ore became strongly sulphide with a small amalgam production. In the four months following the treatment of oxidized ore, the average production of amalgam was 20 oz. per day of an average value of \$2.62 per ounce.

During the first two months of operation the plates were dressed once per shift, or three times per day. Later they were dressed six times per day, and scraped as clean as possible in the daily clean-up. In spite of

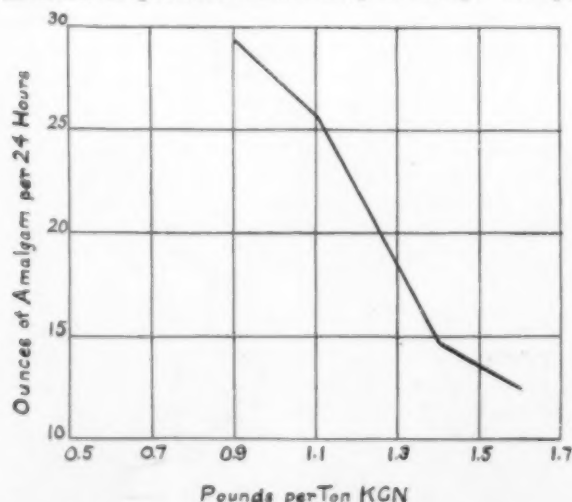


FIG. 8—EFFECT OF STRENGTH OF CYANIDE SOLUTION ON RECOVERY OF AMALGAM WHEN AMALGAMATING IN CYANIDE SOLUTION

this the plates became hard and the recovery by amalgamation dropped off, the percentage of total extraction by amalgamation falling from 9 per cent to 5 per cent.

The effect of the cyanide solution in hardening the plates and decreasing amalgamation from month to month is shown in Fig. 7. Fig. 8 shows the drop in amalgamation caused by the increased strength of the battery solution. In starting the mill the weak solution was allowed to build up gradually, cyanide being added only to maintain precipitation. The value of ore milled remained about the same during these four months, not varying enough to influence the value of the data. In the second month, where the value of the battery

AMALGAMATION IN CYANIDE SOLUTION

Month	Average Value Battery Heads per Ton	Average Ounces Amalgam per Day	Average Strength Battery Solution KCN Pounds per Ton
1	\$13.66	29.2	0.9
2	16.22	25.9	1.1
3	13.58	14.8	1.4
4	13.35	12.5	1.6

heads increased \$2.50 per ton, the efficiency of amalgamation still continued to drop. The tonnage milled varied between 61.8 tons per day and 67.1 tons, the largest tonnage being handled in the fourth month when the average ounces of amalgam per day was at its lowest.

Leaching

The Dorr classifier delivers a sand product containing 20 to 25 per cent moisture, of which a typical sieve analysis is the following:

on 40	20.5 per cent
through 40 on 60	24.5 per cent
through 60 on 80	18.0 per cent
through 80 on 100	21.0 per cent
through 100	14.5 per cent

The sand is diluted with weak solution to 5 to 1 before going to the air lift, which delivers it at the sand distributors in the leaching tanks. The use of an air lift for the sand instead of a sand pump has proved very satisfactory, the lift giving no trouble and showing no wear except for one nipple, which is replaced about every four weeks. The lift piping is 2½ in. in diameter. The height of lift is 14 ft., with a submergence of 17 ft. The lift does not discharge into launders, but its piping is continued to the center of each leaching tank. Distributors of the revolving-arm type are in use, made by two concerns, but neither operate satisfactorily because of the small tonnage handled.

In filling a tank the drain valve is left open for several hours, when it is kept closed until the tank is partly filled with solution, so that the sand settles in solution. The solution overflow goes to the 3-in. centrifugal pumps.

When full the sand is leveled and strong solution containing 3 lb. KCN and 1 lb. CaO per ton is turned on so as to keep the surface covered for about 12 hr. Then the tank drains for 12 hr. and the cycle is repeated. The strong solution treatment lasts five days, when weak solution is used for washing, followed by a water wash, both extending over two to three days. The draining solution usually runs into the weak gold solution tank for a day, when it is turned into the strong sump, and finally back into the weak after the weak solution and water washes are applied. The turning point in KCN strength depends chiefly on the tonnage of strong and weak solutions.

The tank charges average 180 tons, and when well drained are sluiced out to the tailings flume with a high pressure water hose, one tank being discharged by a man in about 7 hr. The four discharge gates in

each tank are not well located for sluicing, as shoveling and tramping was first used, but discarded when it was found possible to give a tank only three days' treatment with 3 lb. solution. By this change the cost of removal of tailings was reduced from 10 cents per ton to 3.5 cents and the extraction much improved.

Below are tabulated the results of solution samples taken from a tank during its cycle of strong solution, weak solution wash and water wash. The sample taken 24 hr. after the first application of 3-lb. solution is still low in cyanide, but its value shows the dissolving effect of the 1.5-lb. solution during the filling of the tank. These assays are shown graphically in Fig. 9.

GOLD BEARING SOLUTIONS FROM LEACHING SANDS

Hours After First Bath of 3-Lb. Solution	Pounds KCN per Ton	Pounds CaO per Ton	Ounces Gold per Ton	Ounces Silver per Ton	Per Cent Copper
24	1.3	1.2	0.166	0.19	0.088
48	1.9	1.3	0.134	0.43	0.102
72	2.0	1.0	0.126	0.48	0.099
96	2.0	0.9	0.116	0.53	0.105
120	1.8	1.0	0.102	0.42	0.101
144	1.8	0.8	0.086	0.27	0.092
168	0.9	1.0	0.041	0.17	0.037
192	0.6	0.6	0.022	.....	0.024

The soluble values in the sand tailings amount to about 10 cents per ton gold, and 0.15 lb. KCN per ton of ore. A little more washing would cut down losses, but time is not available. The tailings from the above tank contained 0.07 oz. gold per ton and 0.89 oz. silver, or \$1.86. The sand tailings average from \$1 to \$3 per ton, depending on the grade of the heads. The sand is 60 per cent of the ore and the slime 40 per cent, but the total value of sand and slime heads are about equal, as the slime contains 50 per cent more of the values than the sand.

Slime Treatment

The Dorr classifier delivers a slime product of the following sieve analysis:

on 100	3.31 per cent
through 100 on 150	2.88 per cent
through 150 on 200	8.07 per cent
through 200	85.80 per cent

This slime is a very fine slime and not as sandy as slime from fine grinding. This makes the operation of the thickeners and agitators easy, as the slime does not pack after a shut down. It is, however, a rather difficult slime for the filter, and makes cleaning the filter once a week necessary, although the filter is operated only 8 hr. per day.

The slime assays 0.6 oz. per ton gold, 5 oz. silver and 0.15 per cent copper, as compared with sand from the same ore containing 0.45 oz. gold, 2.5 oz. silver and 0.10 per cent copper. The sulphide is also higher in the slime. The slime tailings contain from \$1.50 to \$3 per ton, a considerable part of which is silver, on which the extraction is very low. With the single water spray on the filter, as originally installed, the soluble losses have been high at times, and never under 5 cents per ton.

Precipitation

Both domestic and foreign zinc dust have been used for precipitation. The domestic has caused trouble at times because of the metallic shot it contains, which clogs the emulsifiers unless the zinc dust is carefully screened. Also the domestic zinc dust is not well packed, resulting in considerable loss in shipment, which is not the case with foreign material.

At times the zinc dust consumption is high because of copper in solution, and it varies from 0.7 lb. to 1.25 lb. per ton of ore. During a period in which the zinc dust consumption was 0.73 lb. per ton of ore, the con-

sumption per ton of 1.5 lb. KCN solution precipitated was 0.28 lb., and per ton of 2.5 lb. KCN solution precipitated was 0.15 lb. For all solutions precipitated the zinc dust consumption was 0.2 lb. per ton of solution. Per ton of ore milled 3.4 tons of solution were precipitated. Of this solution 1.2 tons was weak solution and 2.3 tons strong solution.

In starting the mill no cyanide was added to the battery solution or weak solution until it began to carry values picked up in washing. When it became necessary to precipitate, an attempt was made to use as little cyanide as possible because of the high price at that time. Lead acetate was used to assist precipitation, but it was eventually found that satisfactory precipitation could only be obtained regularly when the weak solution contained 1.5 lb. KCN per ton. Cyanide is now added at the weak gold solution tank to bring the strength to 1.5 lb. before precipitation.

No cyanide is added to the strong gold solution tank which averages 2.5 lb. per ton before precipitation. About 0.18 lb. of lead acetate is used per ton of ore. Of this 0.04 lb. per ton of ore is added in the weak gold solution tank, and the balance at the agitators.

The difficulties encountered in attempting to precipitate values from solution of low cyanide content are shown in the following table and in Fig. 10. The results given are averages of several months' operation:

ZINC DUST PRECIPITATION FROM WEAK CYANIDE SOLUTION

Pounds per Ton KCN in Solution	Per Cent of Total Value Precipitated	Pounds per Ton KCN in Solution	Per Cent of Total Value Precipitated
0.65	0	1.3	91.4
0.7	0	1.4	94.6
0.8	43.4	1.5	94.9
0.9	64.2	1.6	96.6
1.0	57.8	1.7	98.0
1.1	85.7	1.8	95.0
1.2	89.9	1.9	97.9

Effect of Copper on Extraction

The percentage of copper in the battery heads has varied from zero to 1.75 per cent. For a period of a month it has averaged 0.21 per cent. At first the copper gave considerable trouble, and resulted in a lower extraction, especially of the silver, which seemed to be

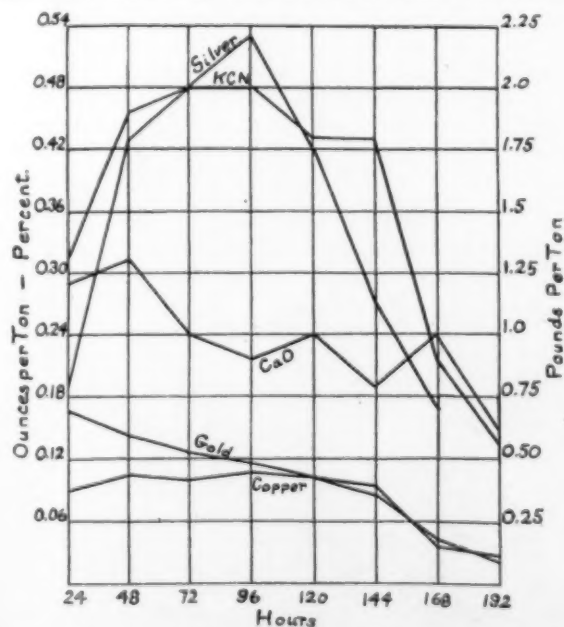


FIG. 9—GOLD, SILVER, COPPER, KCN AND CaO CONTENTS OF SOLUTION DURING A LEACHING CYCLE

present in a more complex sulphide form when copper was high. Lead acetate was tried to assist solution, but the character of the ore is so changeable that it is impossible to attribute improved extraction entirely to it.

During the first months of operation cyanide was used as sparingly as possible, costing 40 cents per pound of NaCN, because it was believed that with the low-grade ore being milled it was cheaper to get a lower extraction with weaker solutions than to aim for a higher extraction with increased cyanide and zinc dust consumption, because of the copper going into solution more easily. The cyanide consumption varied from 1.25 to 1.6 lb. NaCN per ton and the zinc dust consumption from 0.75 to 1.0 lb. per ton while copper-bearing ore was milled.

The copper in the ore does not seem to affect the gold extraction much, but does lower the silver extraction. It was found that by keeping the solutions clean by use of excessive amounts of zinc dust at times when the copper was highest, there was little effect by the copper on the total extraction. When the solutions contain around 0.05 per cent copper no difficulty is experienced either in extraction or precipitation. The precipitate contains much copper and gives a very base bullion in the simple melting process used.

Operating Data and Costs

Tables I and II give a summary of operating data and costs for a certain period of operation. The costs do not include melting. The labor requirements for the mill are: One crusherman, one amalgamator, two battery men, three solution men, one night foreman, one mechanic, and two laborers.

TABLE I—SUMMARY OF MILLING RECORD

Average value per ton.....	\$13.35
Average tons per day.....	66.1
Per cent of possible time run.....	97.5
Cyanide consumed per ton of ore, pounds.....	1.27
Lime consumed per ton of ore, pounds.....	4.29
Zinc consumed per ton of ore, pounds.....	0.73
Lead acetate consumed per ton of ore, pounds.....	0.18
Mercury consumed per ton of ore, ounces.....	0.19
Per cent extraction, gold, bullion and tails.....	87.23
Per cent extraction, silver, bullion and tails.....	43.23
Total per cent extraction, bullion and tails.....	80.44

Paul W. Gaebelein, the present mill superintendent, has kindly made the following statement regarding changes in plant practice since May, 1915:

"1. *Strength of Cyanide Solutions.*—It was decided that, in order to obtain a better extraction of the silver and possibly the gold, the solutions would have to be strengthened, and this was done starting May 1. The strong solution was raised to an average of 5 lb. per ton KCN, and the weak solution to 2.5 lb. KCN per ton.

TABLE II—DISTRIBUTION OF MILLING COSTS

	Per Ton of Ore
Agitation and thickening.....	\$0.052
Amalgamation.....	0.023
Assaying.....	0.117
Clarifying and precipitation*.....	0.233
Classifying.....	0.009
Cleaning up mill.....	0.043
Crushing.....	0.143
Cyanide**.....	0.509
Experimental.....	0.080
Filtration.....	0.038
General mill expense.....	0.100
Heating.....	0.058
Leaching.....	0.041
Lighting.....	0.031
Neutralization.....	0.055
Power.....	0.002
Pumping solutions and handling pulp.....	0.046
Sampling.....	0.025
Shoveling in bins.....	0.004
Stamping.....	0.289
Superintendence.....	0.143
Tailings disposal.....	0.037
Watchman.....	0.025
Total.....	\$2.103

*Zinc dust, 22 cents per pound.

**Sodium cyanide, 40 cents per p

By adding cyanide to the flow of pulp entering the agitation tanks, the strength of solution in the agitators was kept at about 3.5 lb. KCN. The result of strengthening the solutions became apparent at once. The gold extraction has increased to 89 per cent and the silver extraction to between 50 and 55 per cent. The consumption of cyanide also increased, but not to a great extent. The normal consumption with the strengths of solution given above and with an average value of ore of \$24 per ton, averages 2.5 lb. per ton milled.

"2. *Amalgamation.*—The plates at the battery were retained. Some experiments were made with a view to amalgamating the sand tailing as it was discharged from the leaching vats, but the results showed that this could not be done and a saving made which would justify the removal of plates at the battery. At present the plates save a varying amount of free gold. The average for the last four months may be taken at 12 oz. of amalgam per day of an average value of \$5.50 per ounce, or a saving of approximately \$1 per ton of ore milled.

"3. *Slime Treatment.*—Experiments were being conducted in this department which may be outlined as follows: The filter is served by a 20-ft. by 16-ft. Dorr agitator used as a stock tank. This agitator was being run full, and the increased extraction by this method over the former method of keeping the pulp level lower was noted. The increased agitation showed a saving of approximately 75 cents per ton, accounted for by the fact that the pulp receives approximately 8 hr. longer agitation, and the barren, strong solution comes in contact with the pulp just before entering the agitator.

"4. *Filtration.*—The Portland filter in use gives excellent satisfaction. The washing of the cake, however, was not as good as could be obtained, and to increase the efficiency at this point three lines of spray nozzles were installed. Each line has three nozzles, which force the water under pressure into the cake, and which keep the entire surface of the cake covered with a fine film of water. The use of the sprays has lowered the dissolved loss in the cake considerably, and by manipulation of the nozzles the solutions are easily kept in balance.

"5. *Free Gold in Sand Tailings.*—The sand tailing has been subjected to amalgamation as noted previously. The results have been rather negative. In looking for the reasons for this it was found that the free gold in the tailing was coated and very rusty. For this reason it probably escaped the battery plates. Determinations as to the amount of free gold being lost in

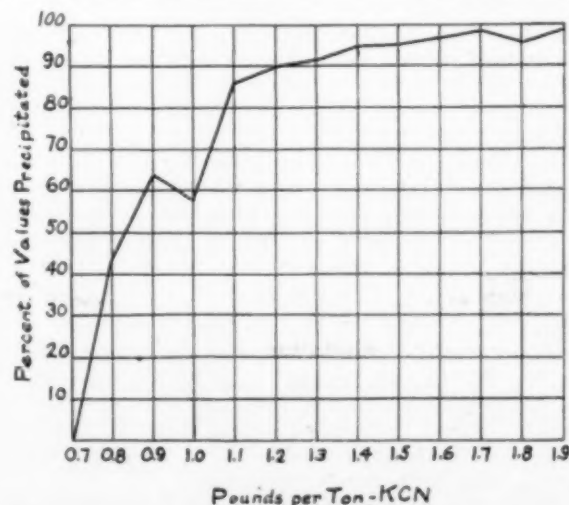


FIG. 10—EFFECT OF STRENGTH OF SOLUTION ON PRECIPITATION OF GOLD AND SILVER FROM CYANIDE SOLUTIONS WITH ZINC DUST

the sand tailing are now being made. The amalgamation of the tailing has shown an average recovery of 2.5 cents per ton of sand. This would tend to show that the loss in the sand tailing in free gold is something over 3 cents per ton.

"6. *Extraction.*—The extraction at the present time, on ore averaging \$24 per ton, is 85.5 per cent. With the grade of the ore at \$20 or over, the ore carries a very considerable amount of easily soluble copper, and this interferes considerably. With a little lower grade of ore, and a consequent lower copper content, it is expected that the extraction will show an improvement over the figures given above."

Metastability of Metals

BY A. VOSMAER

In continuation of the article on the same subject in the issue of Sept. 1 of this journal, on the metastability of bismuth, antimony, potassium and copper, I shall now give a brief account of the publications of Prof. E. Cohen of the Van't Hoff Laboratory, Utrecht, in the *Transactions of the Royal Academy of Science, Amsterdam, Holland*, on the metastability of other metals.

The importance of the subject may well be judged from Professor Cohen's statement: "Physical constants of metals, as they are given to us for the present, have to be considered as chance values, which are a function of the past thermal history of the material experimented upon." (*Zeitschrift für Physikalische Chemie*, 1915). All of us who have to do with physical constants are fully aware nowadays that the greater majority of figures given in the usual tables are nothing but approximations, good enough for orientation, but no more than that, and certainly they are far away from being as accurate as is suggested by the number of decimals which are usually given. Accurate recent determinations of the electric conductivity of "pure copper" of recent date, range from 62 to 65.2, so we should be very cautious when trusting on figures for properties.

To Cohen we are obliged for the explanation *why* it is that there is such a diversity in the figures for physical constants; indeed there is very little constancy in them. Cohen has conclusively shown that if a sample of a metal is chemically pure, this does not necessarily mean that it is also physically pure; that is, a 100 per cent metal *M* may be composed of *b* per cent alpha *M*, *c* per cent beta *M*, *d* per cent gamma *M*, etc.

The allotropic modifications of a metal exercise a very marked influence on its properties and for this reason a figure for some property is a chance figure, its value depending on the ratio of alpha, beta, gamma, etc., modifications in the sample. Add to this the fact that the state of molecular equilibrium is not the most frequent one in ordinary metals and that, on the contrary, all metals are as a rule in a metastable state, and it will be easily understood that the past history of a metal or alloy is of paramount importance because it determines the mutual ratio of allotropic modifications. It goes without saying that the *thermal* past history is of chief importance in this connection.

Allotropy of Cadmium¹

Matthiesen's researches on the electric conductivity of metals (1862) are familiar to every student. In fact, notwithstanding the early date of his experiments, his figures are quoted in a great many instances, and some still accept Matthiesen's standard copper = 100, although modern copper has a conductivity higher than

100, according to this scale, and although the modern system of units should be preferred to any arbitrary scale of obsolete character. Even Matthiesen in his day noticed for cadmium a marked molecular change at a certain temperature (80 deg. C.).

Cadmium, like most metals, shows the usual inertia for change, and the retardation is so great that special precautions have to be taken to notice the change; this is probably the cause why the allotropic modifications have escaped the attention of former scientists. The change, alpha to beta cadmium occurs at 64.9 deg. C. The beta cadmium has a larger specific volume than the alpha modification; this explains Matthiesen's observation that at 80 deg. C. his sample of cadmium was so brittle as to fall to pieces.

From measurements with the pycnometer and the dilatometer, Cohen and his pupils concluded that cadmium has a transition temperature at 64.9 deg. C. and that this metal in general is a metastable system in consequence of the very strongly marked retardation which accompanies the reversible change of the allotropic modifications, both below and above their transition points.

Former experiments on copper and zinc pointed to the desirability of investigating whether or not cadmium did or did not exist in more than two allotropic modifications, and further research proved that, like copper and zinc and other metals, cadmium may exist as alpha, beta and gamma cadmium, the proportions of which depend on the past history of the sample, and this being so, the transition point 64.9 is only an apparent one. It seems probable that above 100 deg. C. the gamma cadmium is the stable form and below 50 deg. C. the alpha cadmium, so that in between 100 deg. and 50 deg. cadmium is chiefly beta cadmium.

The exact behavior of cadmium is of paramount importance for the construction of standard cells as each cadmium modification has an electrolytic potential of its own.

Ordinary cadmium has to be stabilised to the alpha form before use in a cell, if not the "standard" voltage is bound to vary, to decrease, until all the metal has been changed to alpha cadmium.

It may be well to mention here that the metastable transition point of the reaction alpha cadmium \rightleftharpoons gamma cadmium is 94.8 deg. C., and that if one gram-atom of alpha cadmium is transformed into gamma cadmium, the change is accompanied (at 18 deg. C.) by an absorption of 739 gram calories. Electrolytically deposited cadmium is not the stable alpha but the unstable gamma cadmium. This fact is quite in accordance with what should be expected and is of practical importance since the method of making cadmium cells is to deposit the metal electrolytically. This is another instance of the common phenomenon that it is not the stable modification of a metal that is first formed, but the stable form has to be reached via unstable forms.

The conclusions arrived at are: First, that the metal cadmium, as familiar to us is a metastable system containing more than two allotropic modifications, and, second, many of the mysterious phenomena belonging to cadmium cells can be explained when taking into consideration the above mentioned fact.

Allotropy of Lead²

Rather large discrepancies in the physical constants given for lead indicate that here again we have to do with a metal in more than one modification.

The density of purest lead (Kahlbaum 0.001 per cent Cu, 0.0006 Fe) taken as 11.324, increases to 11.341 after treatment at 15 deg. C., it decreases again to

¹Communications, Oct., 1913; May, 1914; Oct., 1914; Jan., 1915.

²Communications of Nov., 1914; Jan., 1915.

11.313 after treatment at 50 deg. C., and it increases again to 11.328 after treatment at 25 deg. C.

The experiments have not yet been concluded, but from what could be observed it is evident that lead, as it has been known up to the present, forms a metastable system containing simultaneously several allotropic modifications of this metal.

The well known form of lead as a lead-tree is one of the metastable modifications.

Allotropy of Zinc²

Scientists seem to have recognized as early as a century ago that zinc is not always the same substance. Practical men have known as long as they have used zinc that one of its peculiarities is that in summer time it expands, but after return to average temperature it does not return to its original dimensions.

In a cold winter zinc contracts but never again resumes exactly the original length, and everyone familiar with zinc roofing knows that zinc should never be cut lengthwise, but always crosswise, though the greater length lengthwise would encourage one to do otherwise if he has to make long strips for tubing or other building purposes.

Practical men know that new zinc possesses that property of not resuming again its original length in a much greater degree than old zinc. Real trouble may result from neglecting the fact that zinc, and more especially sheet zinc, is a metal not to be trusted as regards its length. In case we have circular discs, as is often the case with instruments, warping is the effect of said unequal behavior lengthwise and crosswise the direction of rolling.

The researches of Cohen have not elucidated the strange phenomena. They are strange unless they also can be attributed to metastability at ordinary temperatures.

Practical men also know that zinc cannot be rolled unless heated to a temperature of about 120 deg. C., and they also know that zinc can very easily be pulverized when heated to about 200 deg. C. Cohen did find that prolonged heating to 25 deg. C. had a very marked influence on the density of the zinc. A considerable contraction occurred. Further data are promised by Cohen.

For another transition point, temperatures of 350 deg., 321 deg., 330 deg. 300 deg. are given by different authors, also 170 deg., so that for the present it is best to wait until Cohen and his collaborators will have finished their determinations.

Allotropy of Sodium

The change from alpha sodium to beta sodium does not occur, but beta sodium changes to alpha at a temperature of about 95 deg. C. The transformation of sodium evidently is a case of monotropy that means that the change of one modification into the other is not reversible, it goes one way only. For the present this fact is hardly of any technical importance.

The lesson to be learned from these results is that all numerical data bearing on physical constants have to be revised or checked. No figures should be trusted, and experiments should be carried out on pure metals in their stabilized form. Physical "impurities" in the form of allotropic modifications influence the properties quite as strongly as chemical impurities.

The Explosibility of Acetylene is the title of technical paper 112 of the Bureau of Mines. Results of experiments on acetylene-air mixtures and their relation to mining are given. The authors are G. A. Burrell and G. G. Oberfell.

²Communicated Nov., 1913; May, 1914; Oct., 1914.

Thermal Principles of the Blast Furnace

BY J. E. JOHNSON, JR.

(Concluded from page 910)

The Thermal Effect of Loss of Fuel By Solution

This is a subject which has been little understood, although as early as 1879 Gruner stated that the condition of ideal working required the fuel burnt by the blast at the tuyeres to be a maximum and that dissolved by the oxygen of the charge a minimum.

Prof. J. W. Richards in a brief paper before the International Congress at Düsseldorf in 1910 has attempted to refute this theorem in regard to furnaces requiring little hearth heat such as charcoal furnaces working on rich ores and therefore producing little slag. In this case Professor Richards claims that Gruner's "ideal working" would be wasteful, and greater economy is obtained by departing from it as far as possible. I am unable to accept this conclusion for two reasons. First, I have myself run a charcoal furnace on rich ores, and it is a matter of sad experience with me that when the departure from Gruner's ideal working is considerable, as shown by the small quantity of blast required to burn a pound of fuel the fuel economy is poor, and when the quantity of blast to burn a pound of fuel goes up the fuel economy increases in the same proportion, in exact accordance with Gruner's theorem. Second, Professor Richards' conclusions are contrary both to the double thermal equation, which I have outlined above, and to the old-style heat balance, even for conditions entirely outside those of present practice.

TWOFOLD FUNCTION OF THE CARBON

Just why Gruner's theorem should be true is not apparent on the surface. We naturally think that as the purpose of the blast furnace is to reduce iron ore with carbon, the sooner the carbon starts on its task the better. The reason this is not true depends fundamentally upon the fact that the carbon has to perform two functions and that its capacity for the two tasks is very different. One of its duties is to reduce the iron ore by carrying off the oxygen, the other is to supply the heat for this reaction which is highly endothermic and for the other requirements of the process which are just as important. Referring to Table III it will be seen that when carbon burns to CO, it develops 5470 B.t.u. per pound of O consumed, while the dissociation of iron oxide absorbs about 7500, this varying slightly with the oxide. If the carbon is burnt only to CO the conditions are much worse since in that case the heat developed per pound of oxygen is only 3280 B.t.u.; less than half as much as the removal of the same quantity of oxygen from the ore requires, so that for purely thermal reasons we must have in this case about twice as much carbon as would suffice for reduction.

From the thermal balances already given it may be seen that the total heat required is about twice as great as the reduction heat, and on this basis the surplus of carbon required for heat development over that for oxygen removal is still greater. The greater includes the less, and our problem is then one of heat development, not of oxygen removal.

Turning then to the heat developed, that per pound of carbon burnt to CO is 4375 B.t.u. and per pound burnt to CO₂ is 14,750 more than three times as much. We have already seen that the carbon necessary for heat development is two or three times as large a quantity as can be oxidized by the oxygen of the ore, therefore in order to burn it with any degree of completeness we must have oxygen from some other source. This source must obviously be the blast. We have seen that the heat developed for one unit of oxygen per unit

of carbon (producing CO) is less than one-third of the heat developed for two units of oxygen per unit of carbon (producing CO₂).

Turning this statement around we may say that the second unit of oxygen develops over one-half more heat than the first or that the rate of heat development after consuming the first unit of oxygen is much more rapid, in proportion to the oxygen used, than the rate up to that point. In other words, the more oxygen we deliver to carbon the more heat we shall get in an increasing degree right up to the point of saturation, CO₂.

These facts are all the results of a single cause, that the addition of the first unit of oxygen to carbon results in its conversion from the solid state into the gaseous with the absorption of a large amount of latent heat of vaporization exactly as when ice is converted to water and the water to steam. The second unit of oxygen develops 10,400 B.t.u. per pound of carbon, if the first did as much the heat developed per pound of carbon burnt to CO₂ would be 20,800 B.t.u., instead of the 14,750 actually developed; the 6050 B.t.u. which disappear represents the latent heat of gasification of the carbon.

THE OXYGEN WHICH CAN BE IMPARTED TO THE CARBON IS LIMITED

Now we are strictly limited in the amount of oxygen we can impart to the fuel in the hearth by the fact that CO₂ cannot exist at all in the presence of incandescent carbon, therefore if we burn *all* the carbon of the fuel to CO at the tuyeres we have reached the limit, and any carbon which is dissolved in the upper part of the furnace and fails to reach the tuyeres deprives us of the power of imparting a corresponding amount of oxygen, which deficiency can never be made up and represents a net loss of heat development when the gas is discharged from the stock.

MINIMUM AMOUNT OF CARBON HAS SUFFICIENT OXYGEN-CARRYING POWER

In order to confirm this conclusion, let us take the case to the limiting condition. Let us suppose that CO could be oxidized entirely to CO₂ by oxygen of the ore, then the heat developed per pound of carbon would be 14,750 B.t.u., and let us assume that the minimum heat requirements are 75 per cent more than the heat of reduction which for Fe₂O₃ is 3145 B.t.u. per pound of iron, so that the total requirements per pound of iron would be 5500. Then 0.373 lb. of carbon would be required per pound of iron, and if this were all burnt to CO at the tuyeres (Gruner's ideal working) it would take up $0.373 \times 4 \div 3 = 0.497$ lb. of oxygen there and would require as much more from the ore to saturate it, producing all CO₂ at the top of the furnace. The oxygen per lb. of pig iron in Fe₂O₃ is $0.95 \times 0.428 = 0.406$ lb., which would convert the CO formed at the tuyeres to 82 per cent CO₂ and 18 CO, about the equilibrium ratio for 900 deg. as we have already seen. In other words, the theoretical minimum of carbon would have oxygen-carrying power sufficient to reduce the ore completely, and if any of the possible oxygen be lost by the failure of a part of the carbon to reach the hearth and take up its share there, the total supply would be insufficient for the oxidation of the carbon to this equilibrium ratio.

COMPARATIVE RESULTS WITH VARYING SOLUTION LOSS

In order to show the facts in regard to this question graphically I have made an analysis of it by taking the solution loss as the independent variable which brings out some facts that are the exact opposite of generally accepted opinion.

For simplicity I have assumed that the iron produced contains no manganese and phosphorus and that the silicon is 1.5 per cent, this assumption gives results practically identical with those which would result from the use of the actual percentages of these three metalloids in ordinary steel-making irons.

Let us assume as the basic case a furnace working with a slag volume of 50 per cent and making a ton of iron containing 1½ per cent Si with a ton of coke (2240 lb.) and blown in four different cases with 50, 55, 60 and 65 cu. ft. of actual air at 70 deg. Fahr. Let us assume that the coke contains 2000 lb. of fixed C and that 80 lb. of this are required for carbonizing the iron, leaving 1920 lb. for combustion. Let us disregard the work done in the hearth altogether and consider the materials which descend to the hearth as discharged from the shaft in the solid condition at the top of the bosh. We have already seen that such a calculation is possible in spite of our complete ignorance of the temperatures at which the gases in the charge are driven off and consequently of how much heat it required to raise them to this unknown temperature. We charge against the total heat received plus that developed in the shaft, the heat required for the chemical reactions of the shaft and that discharged from the bottom of the shaft and by radiation, the balance is then credited to the top gases, and from it we can readily figure the temperature of the latter. The temperatures found by this method in the different cases will evidently give us a measure of the effect of solution loss in the shaft of the furnace.

EFFECT OF SOLUTION LOSS ON HEARTH HEAT

The effect of solution loss on hearth heat is simple, almost obvious. The chart, Fig. 1, gives hearth heats developed not per pound of coke charged, but per pound of coke burnt in the hearth, with oxygen from the blast. Obviously any coke which does not reach the hearth can furnish no such heat at all, and it is further obvious on reflection that oxygen from other sources than the blast even set free in the hearth does not count in the development of hearth heat because any such oxygen involves the dissociation of other compounds, FeO, SiO, and the like, and there is not enough heat developed by the combustion of such oxygen with carbon to keep the reaction going without additional heat from some other source. So of course there is none available above the critical temperature, therefore no hearth heat developed at all.

Obviously then the hearth heat developed per pound of fuel is directly proportional to the cubic feet of blast required to burn that fuel, other things being the same, that is, the more blast we blow per pound of coke the more hearth heat per pound of coke we develop in exactly the same proportion.

In making the calculation, I have assumed that the blast was dry since this saves much complication in regard to the shaft heat calculations, and the comparative results are not affected at all thereby.

Now our calculation in detail becomes as follows:

CASE 1.—1920 lb. of carbon for combustion (by blast and ore together) equals 0.857 lb. per pound iron; 50 cu. ft. of blast at 75 lb. per 1000 cu. ft. equals 3.75 lb. and 23 per cent of this gives 0.864 lb. O. Assume the ore to be Fe₂O₃ and the iron to contain 95 per cent Fe and we obtain 0.407 lb. of O per lb. iron from this source.

0.015 lb. Si carries with it 0.017 lb. O, and assuming that 0.1 lb. of H₂O is decomposed in the shaft which is about in accordance with Mathesius' and Cornell's figures we obtain 0.089 lb. O from this source. Then the total O per pound of iron is as follows:

From blast (dry).....	0.864
From SiO_2 reduced.....	0.017
From Fe_2O_3	0.407
From H_2O decomposed in shaft.....	0.089
Total O =	1.377
O required for .857 C to $\text{CO} = .857 \times \frac{16}{12} =$	1.143
O left for CO to $\text{CO}_2 = 1.377 - 1.143$	0.234
Carbon to CO $= (1.143 - .234) \times \frac{3}{4} =$	0.681 lb.
Carbon to $\text{CO}_2 = 0.234 \times \frac{3}{4} =$	0.175 lb.

Assuming that 10 per cent of the oxygen of the ore is removed by solid carbon in the hearth in accordance with our previous conclusion we have the oxygen in the hearth as follows:

From blast.....	0.864 lb.
From SiO_2	0.017
From 10 per cent of O in ore.....	0.041
	0.922

The carbon consumed in the hearth is therefore $0.922 \times \frac{3}{4} = 0.691$ lb.

The CO resulting from the combustion of this is $0.691 \times 29.85 = 20.6$ cu. ft.

The nitrogen of the blast is $.79 \times 3 \times 50 \times 492 \div 530 = 36.9$, add 20.6 cu. ft. CO and we have 57.5 cu. ft., total gas coming in from hearth.

The sensible heat of this gas at 2750 deg. = 58.8 B.t.u. per cubic foot.

Heat brought into shaft by gas from hearth $57.5 \times 58.8 = 3380$ B.t.u.

Of the 0.857 lb. carbon charged there is consumed in the hearth 0.691 lb. leaving 0.166 lb. to be consumed in the shaft by oxygen from the ore.

This requires $0.166 \times 1.33 = 0.222$ lb. oxygen. The ore contains 0.4070, but 10 per cent is not available in the shaft, so all we have available is $0.407 \times 0.90 = 0.366$ lb., deducting 0.222 lb. from this we have left 0.1440 O from the ore to which we add $0.1 \times 8 \div 9 = 0.089$ lb., the oxygen from the water dissociated in the shaft, making 0.233 lb. O for converting CO to CO_2 .

This checks with the total oxygen calculation given before, which is much simpler but does not separate the C into the two portions that burnt to CO and that to CO_2 in the shaft. We can now figure the heat developed in the shaft very simply.

0.166 lb. C burnt to CO develops $.166 \times 4375 =$	727 B.t.u.
$0.233 \times \frac{3}{4}$ C as CO burnt to CO_2 develops $0.175 \times 10,400 =$	1820
Add to this the heat brought in from the hearth.....	3380

Total heat for operations in the shaft.....	5927 B.t.u.
To reduce 0.9 of ore, the heat consumed is.....	2670 B.t.u.
To decompose $\frac{1}{2}$ lb. stone.....	405
To heat slag forming materials ($\frac{1}{2}$ lb.) to 2750° F.....	300
To heat iron (1 lb.) to 2750° F.....	480
To heat carbon in iron.....	45
To evaporate 0.25 lb. H_2O to steam.....	280
To decompose 0.1 lb. H_2O from steam.....	580

4760 B.t.u.

On the basis of our assumption that the water evaporated decomposed is a certain percentage of the weight of the iron these items all depend upon the weight of iron produced and vary with it, when we assume the weight of iron produced per pound of coke to vary as we presently shall.

In addition we have radiation which, on the basis of our previous data is 440 B.t.u. per pound of iron under these conditions but is constant and does not increase with the iron per pound of coke, and the heat required to bring up to the critical temperature the coke that goes down out of the shaft into the hearth which, of course, changes with the weight of coke consumed in the hearth.

In this case it is $0.691 \text{ C} \times \text{total heat of coke, } 1159 \text{ B.t.u.} = 800 \text{ B.t.u.}$

Adding these items we have as the total heat required in the shaft

Constant heat required for pound of iron as above.....	4760
Required for heating coke.....	800
Required for radiation.....	440
	6000
Total heat for operation in shaft.....	5927
Balance (B.t.u.).....	-73

This is 73 B.t.u. more than the heat developed in the shaft, but let us ignore this fact for the present and say that it merely corresponds to the fact that furnaces never run with so small an amount of blast as 50 cu. ft. per pound of coke, in other words solution loss is never so bad as we have assumed. Presently we shall see that this is not necessarily true, but we will not consider that now, merely assuming for the present that this represents the impossible case.

To compute the temperature of the top gases we can figure their volume and take their specific heat per cubic foot as 0.02 since this is extremely close and the error introduced by that assumption is not important enough to justify an accurate calculation of this factor.

The total carbon from the coke is 0.857 lb. or $0.857 \times 29.85 =$	25.6 cu. ft.
Nitrogen as above.....	36.9 cu. ft.
CO_2 from $\frac{1}{2}$ lb. of stone (12 per cent C) $= 0.06 \times 29.85 =$	1.8 cu. ft.
H_2 from 0.1 lb. $\text{H}_2\text{O} = 0.1 \times 1/9 \times 178 =$	2.0 cu. ft.
	66.3

The specific heat of this at 0.02 B.t.u. per cubic foot is 1.33, hence we get $-73 \text{ B.t.u.} \div 1.33 = -55 \text{ deg. Fahr.}$

This temperature is normally measured from 32 deg. Fahr., but if we do that we should take account of the heat of the materials charged and it is simpler to reckon the temperature of the top gas from that of the raw materials which makes no appreciable error. Taking this temperature at 60 deg. we have the top gas passing off in this case at $60 - 55 \text{ deg.} = +5 \text{ deg. Fahr.}$

The gas analysis in this case is as follows:

CO_2 from combustion $0.175 \times 29.85 =$	5.3 cu. ft.
CO from stone as above.....	1.8 cu. ft.
Total CO_2	7.1
CO from combustion of $0.857 - 0.175 = 0.682 \text{ C}$	20.3
$0.682 \times 29.85 =$	20.3
Nitrogen as above.....	36.9
Hydrogen from dissociation of H_2O as above.....	2.0
	66.3
	100.0

CASE 2.—We now assume that the solution loss is less, so that 55 cu. ft. of blast at 70 deg., 10 per cent more than in the previous case, are required to burn a pound of coke, other conditions remaining as before.

The oxygen in the blast now becomes $0.864 \times 1.1 = 0.95$, and the other sources of oxygen remaining the same, the total becomes $0.017 + 0.089 + 0.407 + 0.95 = 1.463$, and the oxygen to burn all the coke to CO remaining as before 1.143 lb., the oxygen available for CO to CO_2 is $1.463 - 1.143 = 0.32$ lb., which burns 0.24 lb. C to CO.

The coke burnt in the hearth is $\frac{1}{4} (0.95 + 0.017 + 0.041) = \frac{1}{4} \times 1.008 = 0.256 \text{ lb.}$	
CO formed by this is $0.256 \times 29.85 =$	22.6 cu. ft.
The nitrogen is $36.9 \times 1.1 =$	40.6

Total gas coming in from hearth =	63.2 cu. ft.
Heat brought in by this at 2750 deg. $= 63.2 \times 58.8 =$	3710
C burnt to CO in shaft $= 0.857 - 0.256 = 0.601$	
Heat produced by this $0.601 \times 4375 =$	438
C as CO burnt to CO_2 in shaft as above $0.32 \times \frac{3}{4} = 0.24 \text{ lb.}$	
Heat produced by this $0.24 \times 10,400 =$	2495
Total heat available in shaft =	6643
Heat required per lb. of iron as before.....	4760
To bring coke burnt in hearth to 2750 deg. $= 0.256 \times 1159 =$	877
For radiation.....	440
	6077
Total heat available for shaft.....	6643

Surplus for gas $= 6643 - 6077 =$	566 B.t.u.
Gas volume is as before except the nitrogen is increased 10 per cent	
$= 3.7 \text{ cu. ft., } 66.3 + 3.7 =$	70 cu. ft.
Heat required to raise gas 1 deg. at 0.02 B.t.u. per cu. ft. sp. ht.	
of gas $= 70 \times 0.02$	1.4
$566 + 1.4 = 404 \text{ deg.} + 60 \text{ deg.} = 464 \text{ deg.}$ discharge temperature of the gas.	

The gas analysis in this case is as follows:

Total carbon gas from fuel as before is 25.6 cu. ft., the CO_2 = $0.24 \times 29.85 = 7.26$ cu. ft. and the CO is 18.4. The carbon dioxide from the limestone is 1.8 which added to 7.2 gives 9 cu. ft., the H_2 as before is 2 cu. ft. and the nitrogen is $36.9 \times 1.1 = 40.6$.

Then the percentages are

CO_2	9. $\div 0.70 =$	12.8
CO	18.4 $\div 0.70 =$	26.3
H_2	2. $\div 0.70 =$	2.9
N	40.6 $\div 0.70 =$	58.

CASE 2A.—Now let us assume that since the hearth heat as already shown is increased in proportion to the blast per pound of coke we increase the burden of ore and stone by 10 per cent also. The oxygen from the blast is 0.95 lb. and that from other sources is increased 10 per cent so becomes

From SiO_2	0.019 lb.
From ore	0.448
From H_2O	0.097
	0.564 lb.

which added to 0.95 gives 1.514 lb. total. Deducting from this the oxygen for 0.857 C to CO, 1.143 lb. we have left 0.371 lb. O for CO_2 , which suffices to burn 0.278 C as CO to CO_2 .

The oxygen available in the hearth is $0.95 + 0.019 + 0.045 = 1.014$, which burns $1.014 \times \frac{3}{4} \text{ C} = 0.76 \text{ C}$, leaving $0.857 - 0.76 = 0.097 \text{ lb. C}$ to be burnt to CO in shaft.

0.097 C to CO produces $0.097 \times 4375 =$	424 B.t.u.
0.278 C as CO to CO_2 gives $0.278 \times 10,400 =$	2895 B.t.u.
CO from hearth $0.76 \times 29.85 =$	22.7
N from hearth as before	40.6

Heat carried from hearth to shaft by gas $63.3 \times 58.8 =$	3720
Total heat for shaft =	7039

Heat required.	
For iron, etc., as before $\times 1.1 = 4760 \times 1.1 =$	5236
For heating coke $0.76 \times 1159 =$	881
For radiation	440
Total	6557

Excess available for heating gas $7039 - 6557 = 482$ B.t.u. The volume of gas and its analysis are as follows:

Total carbon gas from fuel as before	25.6 cu. ft.
Carbon as CO_2 from fuel $0.278 \times 29.85 =$	8.3 cu. ft.
CO by difference	17.3 cu. ft. 24.6 per cent
CO_2 from stone 2 cu. ft.	
Total $\text{CO}_2 = 2 + 8.3 =$	10.3 "
$\text{H}_2 = 2 \times 1.1 =$	2.2 "
N =	40.6 "
	57.6 "
	70.4 cu. ft. 100.0 per cent

The specific heat of this at 0.02 is 1.41 and the discharge temperature of the gas is $482 \div 1.41 = 340$, which added to 60, gives 400 deg.

CASE 3.—Solution loss is so much decreased that 60 cu. ft. of blast are required per pound of coke, other conditions being as in Case 1.

Oxygen in blast is $0.864 \times 1.20 =$	1.037
Other oxygen as in case I $0.017 + 0.407 + 0.089 =$	0.513
Total oxygen $1.037 + 0.513 =$	1.55 lb.
Oxygen for 0.857 C to CO as before	1.143

Oxygen for CO to CO_2	0.407
C as CO to $\text{CO}_2 = 0.407 \times \frac{3}{4} =$	0.305 lb.

Oxygen in hearth $0.017 + 0.041$, (as in Case I), $+ 1.037 =$	1.095 lb.
Carbon burnt with this	0.823 lb.
Carbon left to be burnt to CO in shaft $0.857 - 0.823 =$	0.034 lb.

Heat developed by this $0.034 \times 4375 =$	149
Heat developed CO to CO_2 $0.305 \times 10,400 =$	3171
Volume of CO from hearth $823 \times 29.85 =$	24.6 cu. ft.
Volume of U from hearth $36.9 \times 1.2 =$	44.3 cu. ft.

Total volume of gas from hearth	68.9 cu. ft.
Heat brought in by this $68.9 \times 58.8 =$	4050
Total heat for shaft	7370

Heat required	
For iron, etc., as in Case I	4760
For heating coke $823 \times 1159 =$	955
For radiation	440

Total heat required in shaft	6155
Heat available for gas $7370 - 6155 =$	1215 B.t.u.

Volume and composition of gas.

Total carbon gas from fuel as before	25.6
CO from fuel $0.305 \times 29.85 =$	9.1 cu. ft.
CO_2 from fuel $25.6 - 9.1 =$	16.5 cu. ft. 22.5 per cent
CO_2 from stone 1.8	
Total CO_2 $1.8 + 9.1 =$	10.9 "
H_2 as in Case I	2.7 "
N	60. "
Total	73.7 "
	100.0 "

Specific heat of this at 0.02 per cubic foot = 1.47.

Temperature of top gas = $1215 \div 1.47 = 826 + 60 = 886$ deg. C.

CASE 3A.—Blast as in Case 3 and burden increased in same proportion, 20 per cent.

Oxygen from blast 1.037, other oxygen as in Case I, $\times 1.2 = (0.017 + 0.407 + 0.089) \times 1.2 =$	0.616
	1.037

Oxygen for 0.857 C to CO	1.143
O for CO to $\text{CO}_2 =$	0.51

C as CO to CO_2 $0.51 \times \frac{3}{4} =$	0.383 lb.
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O in hearth from blast	1.037 lb.
From other sources as in Case I, $\times 1.2 = 0.058 \times 1.2 =$	0.070 lb.

Total O in hearth	1.107
This burns 0.832 C to CO and leaves $(0.857 - 0.832) = 0.025 \text{ C}$ to burn to CO in shaft.	

Heat from this $0.025 \times 4375 =$	110 B.t.u.
Heat from 0.832 C as CO to $\text{CO}_2 = 0.832 \times 10,400 =$	3980 B.t.u.
CO from hearth $0.832 \times 29.85 =$	24.8
N, as in Case 3	44.3

Total gas from hearth to shaft	69.1
Heat brought in by this $69.1 \times 58.8 =$	4060

Total heat available in shaft	8150
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Heat requirements	
For 1 lb. iron as in Case I, $4760 \times 1.2 =$	5710
For heating coke $0.832 \text{ lb.} \times 1159 =$	965
For radiation	440
	7115

Heat available for gas $8150 - 7115 =$	1035 B.t.u.
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Total volume of gas:	
Carbon gas from fuel	25.6
CO_2 $0.382 \times 29.85 =$	11.4
CO $25.6 - 11.4 =$	14.2 cu. ft. 19 per cent
CO_2 from flux $1.8 \times 1.2 = 2.2$	
Total CO_2 $11.4 + 2.2 =$	13.6 cu. ft. 18.3 per cent
$\text{H}_2 = 2 \times 1.2 =$	2.4 cu. ft. 3.2 per cent
N =	44.3 cu. ft. 59.5 per cent
	74.5
	100.0

Specific heat of this at 0.02 = 1.49.

Temperature of gas $1035 \div 1.49 = 0.695 + 60 = 755$ deg. F.

CASE 4.—Solution loss reduced to zero so that 65 cu. ft. of blast are required to burn a pound of coke, other conditions as in Case 1.

Oxygen in blast $0.864 \times 1.3 =$	1.123
Other oxygen, as in Case I, $0.017 + 0.407 + 0.089 =$	0.513

Total oxygen	1.636
Oxygen for 0.857 C to CO	1.143

Oxygen left for CO to CO_2	0.493
C as CO burnt to CO_2 with this =	0.37

Heat developed in shaft by this $0.37 \times 10,400 =$	3850
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No heat by oxidation of C to CO in shaft	
Vol. of CO from hearth $0.857 \times 29.85 =$	25.60
Vol. of N from hearth $36.9 \times 1.3 =$	48.0

Total gas from hearth to shaft	73.6
Heat brought in from hearth by this $73.6 \times 58.8 =$	4330

Total heat available in shaft	8180
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Heat requirements	
For iron, etc., as in Case I	4760
Heating coke $0.857 \times 1159 =$	995
Radiation	440
	6195

Heat available for gas $8180 - 6195 =$	1985 B.t.u.
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Total gas volume.	
Carbon gas =	26.5 cu. ft.
CO $0.37 \times 29.85 =$	11.1 cu. ft.

CO	15.4 cu. ft. 19.7 per cent
CO_2 from stone 1.8	
Total CO_2 $1.8 + 11.1 =$	12.9
$\text{H}_2 =$	2.6
N =	48.5
	61.3 per cent
	78.3
	100.0

Specific heat of this at 0.02 = 1.566.

Temperature of top gas $1985 \div 1.566 = 1266$ deg. $+ 60 = 1326$ deg.

CASE 4A.—Same as last except burden increased in same proportion as blast to burn a pound of coke, 30 per cent.

Oxygen from blast.....	1.123	
Other oxygen, as in Case I, $\times 1.3 =$	0.666	
Total oxygen.....	1.789	
Oxygen for 0.857 C to CO.....	1.143	
Oxygen for CO to CO ₂ in shaft =.....	0.646	
C as CO burnt to CO ₂ with this.....	.485 lb.	
Heat developed by this $485 \times 10,400$		5040
No heat from oxidation of C to CO in shaft		
Gas from hearth to shaft as before 73.6		
Heat brought in by this as before.....		4330
Total heat available in shaft.....		9370
Heat requirements:		
For iron, etc., as in Case I, $\times 1.3 = 4760 \times 1.3 =$		6190
Heating 0.857 coke as before.....		995
Radiation.....		440
Total.....		7625 B.t.u.
Available for gas heating $9370 - 7625 =$		1745 B.t.u.
Total gas volume:		
Carbon gas from fuel.....	25.6 cu. ft.	
CO ₂ 0.485 $\times 29.85 =$	14.5 cu. ft.	
CO.....	11.1 cu. ft.	14.2 per cent
CO ₂ in stone $1.8 \times 1.3 = 2.3$		
Total CO ₂ $2.3 + 14.5 =$	16.8 cu. ft.	21.4 per cent
H ₂ $2 \times 1.3 =$	2.6 cu. ft.	3.3 per cent
N ₂ , as in Case 4.....	48.0 cu. ft.	61.1 per cent
	78.5	100.0

Specific heat of this at 0.02 per cu. ft. = 1.570.

Temperature top gas = $1745 \div 1.57 = 1110$ deg. + 60 = 1170 deg. F.

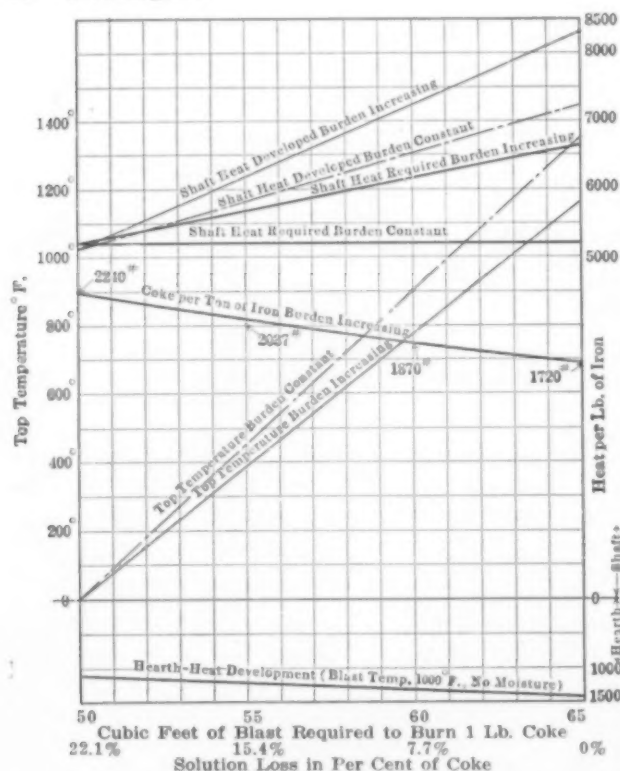


FIG. 3—THE EFFECT OF SOLUTION LOSS ON HEAT DEVELOPMENT AND TOP-TEMPERATURE WITH BURDEN CONSTANT AND WITH BURDEN INCREASING AS SOLUTION LOSS DECREASES

Fig. 3 shows these results graphically. Above the zero line we have the heat developed and that required in each of the four cases and the three sub-cases but in order to have the total correct the heat required to bring the coke up to the critical temperature is deducted from both sides alike. This is perfectly correct, for we could, if we liked, have deducted from the heat brought in by the gases rising from the hearth, the heat required to heat the coke to the critical temperature, and counted the balance as that available for heating the rest of the charge and the gas. We have in fact

virtually done this by adding the heat for the coke to the requirement side instead of subtracting it directly from the heat available side. If we left this in on both sides we should be counting the heat required for the coke twice and should not get a correct total by adding the hearth heat to the above quantities.

We can readily plot the hearth heat below the zero line and the total distance between this and the lines of shaft heat requirements gives the total requirements for the given case. We may obviously assume for case 1 representing 1 lb. of iron that the hearth heat developed is 1100 B.t.u. in accordance with the actual data of operation given above. This is derived by the combustion of that coke which is burnt with the oxygen of the blast or $\frac{3}{4} \times 0.864 = 0.648$ lb. C.

Our diagram of hearth heat is based on 0.85 lb. C burnt with blast and 1100 B.t.u. for 0.648 lb. C corresponds to 1440 B.t.u. per 0.85 lb.; assuming 0.5 lb. moisture per 1000 cu. ft. of blast we find that 1000 deg. blast temperature produces the required amount of hearth heat. Assuming these conditions to remain the same, the hearth heat increases in proportion to the blast per pound of coke as explained above, and starting at 1100 B.t.u. in case 1 it rises to 1430 B.t.u. in cases 4 and 4A.

Let me reiterate here that these calculations show what the thermal condition *would be*, if we could have the amount of solution loss assumed in each case, without asserting that this is possible. We can now proceed to interpret these results.

Analysis of Results

HIGH SOLUTION THE LEFT SIDE OF THE DIAGRAM

Let us return now to the impossible top temperature in Case 1, 55 deg. below the temperature of the entering charge which might seem to indicate that a furnace could not operate under conditions even approximating these.

As a matter of fact furnaces can and do operate under conditions very similar to these and strange as it may seem they do it by increasing the blast temperature. Since the blast constitutes about 80 per cent of the gas, an increase of 200 deg. blast temperature will give an increase of about 160 deg. top temperature and so raise the temperature of the top gas to 165 deg. which is still below the top temperature at which furnaces run. But referring to the diagram we find that for 51.25 cu. ft. of blast the top temperature rises to 100 deg. and adding the 160 deg. for a higher blast temperature we obtain 260 deg. for these conditions, which correspond very closely in all important particulars to those under which many furnaces operate when using much Mesabi ore. It is necessary to emphasize the fact that in such a case more heat is developed in the hearth than is needed there, and that the excess passes up into the shaft and does work there which should have been done by heat of lower temperature under more correct conditions of working. This would leave this hearth heat to be utilized for the final smelting of a larger burden.

This is precisely the condition described before, under which the charcoal furnace was working on wet ore.

The chart shows quite plainly that only about one-fifth to one-fourth as much hearth heat per pound of fuel is generated as of shaft heat, so it is obviously a waste of fuel to employ this hearth heat for use in the shaft just as it would be to employ water from hydraulic pumps under 1200 lb. pressure to feed boilers under 200 lb.

This is in accordance with the general law of thermodynamics that any application of heat at a temperature lower than that at which it is developed results in an increase of entropy and a decrease of availability.

Obviously this corresponds to the case of Cornell as against that of Mathesius. In the latter's case only 1000 B.t.u. of shaft heat were developed per pound of iron, in the former's case 1250 B.t.u., because it was doing work in the hearth that should have been in the shaft and this surplus of high-temperature hearth heat was being largely wasted on low-temperature operations. Probably this was due to incorrect filling or a scaffold causing irregular descent of the charge into the hearth since if it were due to excessive solution loss there would be a deficient development of heat in the shaft whereas there is really an excess so far as our figures give reliable indications.

LOW SOLUTION LOSS THE RIGHT-HAND SIDE OF THE DIAGRAM

Passing now to the other side of the diagram, cases 4 and 4A, the oxygen from 65 cu. ft. of blast plus that from the silicon is exactly enough to burn all the coke without leaving any for the 10 per cent of oxygen from the ore which we have already seen is only removed in the hearth and we may therefore safely admit that this case is beyond the limit of present possibility.

From the detailed calculation it appears that 62 cu. ft. of blast is about the maximum that still leaves carbon enough for the removal of the last 10 per cent of oxygen in the ore and a vertical line in the diagram through this quantity of blast indicates approximately the practical limit in this direction of the amount of blast per pound of coke that can be blown for these conditions, but, of course, if the quantity of fixed carbon in the coke were greater than that assumed as the basis of the calculation, then the theoretical maximum limit of blast per pound of coke would be proportionately raised.

We find in this the probable explanation for the excess hearth heat in the case of Reece, for in my first work on this subject (see the report quoted before) I did not realize that at least 10 per cent of the oxygen of the ore was necessarily removed in the hearth, and since my figures for blast volume based on piston displacement indicated that enough blast was blown to burn all the coke I assumed this to be the case; but these figures for blast volume depend on several allowances and the results are not absolutely positive. They must, therefore, give way to the small extent required by the later deduction founded on more accurate data; that 10 per cent of the oxygen of the ore is removed by direct carbon in the hearth with a corresponding loss of carbon.

The minimum loss is represented by the difference between 65 cu. ft. and 62 cu. ft. of blast per pound of coke or 5 per cent, but as a matter of fact the solution loss is probably never less than 10 per cent and a deduction of 10 per cent from the hearth heat in Reece's case, 1170 B.t.u., would bring it down to 1053 B.t.u., virtually identical with that of Mathesius. This reduction in the amount of total oxygen would also reduce the shaft heat to a figure as close to that of Mathesius as such calculation will ever come honestly.

The better agreement, brought about by this correction, between the results of two cases varying widely in time, place, and conditions, seems to me to confirm both the correctness of the thermal calculation as a whole and the accuracy of our conclusion, as to the removal of the final fraction of the oxygen of the ore in the hearth.

I believe it will be generally admitted that these theoretical maximum and minimum limits of blast blown are in exceedingly close agreement with the facts of practice.

It will be seen that the coke consumption for this high limit of blast blown is about 1800 lb. whereas the results reported by Mathesius are considerably lower

than this, 1682 lb., and the more recent work of Howland at the plant of the Wisconsin Steel Co. has produced a still lower figure, about 1640 lb.

These facts, however, do not in the least controvert our diagram, but rather confirm it, for we have assumed only 1000 deg. blast temperature, whereas these remarkable results were obtained with blast temperatures of about 1250 deg. corresponding to the production of 23 per cent more hearth heat per pound of coke burnt with blast. Sixteen hundred and forty pounds being only 8 per cent less than 1800 lb., it is obvious that enough hearth heat could be developed with about 15 per cent less coke burnt by blast than in our limiting case with 62 cu. ft. of blast; which would correspond to about 53 ft. of blast; this was in fact the precise amount used by Mathesius. Moreover the total carbon in Howland's practice is 93 per cent against 89 per cent as assumed above, while the sulphur in his coke was so low that the critical temperature was probably lowered by the use of a more siliceous slag.

CONDITIONS OF PRACTICE TO WHICH THE DIAGRAM CORRESPONDS. HEARTH HEAT

The condition represented by cases 1 to 4 in which the blast per pound of coke increases without any increase of burden may be compared with either of two conditions in practice. First, we may assume that the blast temperature falls or the humidity rises as the solution loss decreases so that while more coke is burnt in the hearth only the same amount of hearth heat is developed from it.

Second, we may assume that the weight of slag increases as the solution loss decreases and that as the hearth heat increases the heat required above the critical temperature for slag increases in the same proportion, so that left for iron and other hearth requirements is still the same. In either case no more iron could be smelted per pound of coke with low than with high solution loss, thus producing the conditions as to shaft heat which we have assumed.

The latter condition of larger slag volume and lower solution would correspond with lean lump ores, such as are used in the South as compared with the fine sandy but much richer Mesabias.

Such data as I have of cases with approximately the same full consumption in these two dissimilar cases confirm the results of the diagram absolutely, the top temperature being much higher in the case of the low solution loss.

The former case is approximately that of a furnace on old-range ores but with higher humidity and lower blast temperature, so developing less hearth heat per pound of coke but receiving more coke in the hearth on account of low solution loss and in these cases also confirm in a qualitative way the results of the diagram, the top temperatures being much higher under such conditions than in Mesabi practice on the same fuel consumption.

CONDITIONS OF PRACTICE TO WHICH THE DIAGRAM CORRESPONDS. SHAFT HEAT.

This brings our diagram into absolute agreement with practice as regards hearth heat and we may now turn to the question of shaft heat development.

The chart shows that the temperature of the top gases rises almost as fast when the burden is increased in proportion to the blast blown as it does when the burden is not increased at all. This is without any allowance for the fact that the limestone needed would be reduced in proportion to the increased iron produced because of the smaller amount of coke, ash and sulphur to be fluxed. With reasonable allowance for this factor the temperature would be almost the same

with the increased burden as without. This seems very surprising and the reason for it has an important bearing on the whole subject of thermal principles. This reason is that *the heat generated by the oxidation of CO to CO₂ with oxygen from the ore develops more shaft heat than is required for the preparation of the ore from which the oxygen comes.*

We have already seen that the reaction $\text{Fe}_2\text{O}_3 + 3\text{CO} = 2\text{F} + 3\text{CO}_2$ is slightly exothermic—7330 B.t.u. + 7650 B.t.u., but in this case it is much more than slightly so, for the CO brings with it a very large quantity of sensible heat due to the high temperature of itself and its accompanying nitrogen; these contribute far more than enough heat for all the other operations outside of reduction and the net result is that *if the solution loss stayed the same* the top temperature in any given case would drop little or not at all by the addition of more ore, *always provided that enough additional hearth heat were furnished to take care of the added burden in the hearth.* As a matter of fact the solution loss does not stay the same, because the approximate equilibrium between the concentration of CO₂, the fuel and the quantity of ore is disturbed and the increased CO₂ dissolves more coke, this solution is a highly endothermic reaction and it cools off the gas quite appreciably. Our diagram shows quite unmistakably, if the solution loss be diminished so that the coke burnt in the hearth is correspondingly increased and the burden increased in this same proportion that the top gas will become hotter and not colder. Solution loss can be affected in two principal ways, first by changing the characteristics of the coke itself by differences in coal used, method of coking, etc., and by changing the type of ore used. I have never had the opportunity to make a test of the top temperature on cokes of different solubility, but I believe it is well established that top heats on low-fuel runs were higher with old-range ores than they are to-day with large percentages of fine Mesabits producing high solution loss, on the same fuel consumption.

Of course, we do not find in actual practice the top heats shown by the diagram for low solution loss, because as the temperature tends to rise the solution loss rises also and automatically checks it.

RECAPITULATION

Let me reiterate here that this diagram is not intended to show what *does* happen under all conditions, but only to show what *would* happen if starting with given conditions we had a varying solution loss.

The exact conditions assumed are impossible at both ends of the scale as already explained, but the indications of the diagram are certainly in good agreement with the facts of practice in the region of the diagram between 51 and 60 cu. ft. of air per pound of coke. The value of the diagram comes not from any claim to arithmetical exactness, for such a claim would be ridiculous, but from the fact that, starting with the best data obtainable, results have been obtained which are at least truly comparative for the conditions and which are certainly in good agreement with the results of practice within the legitimate range of the diagram. This diagram makes it clear that solution has two effects the results of both of which are to diminish the economy of working of the furnace.

First, it prevents a portion of the coke from ever reaching the hearth and thereby reduces the production of hearth heat, directly in the same ratio.

Second, it reduces the total amount of oxygen which can be imparted to a given weight of coke and thereby diminishes in a greater degree, proportionally, the oxidation of CO to CO₂ in the shaft, which is the prin-

cipal source of heat in that region, so that the development of shaft heat with increased solution loss drops more rapidly than that of hearth heat.

If we were to use some method different from any we now have in operation but nevertheless conceivable, whereby the development of hearth heat per pound of fuel could be noticeably increased we should be under the necessity of increasing the shaft heat just as much, in order to take advantage of it, since we have seen that these requirements for any given case bear a definite relation to each other. The only way we could secure this increase would be by a further oxidation of the top gases and this in turn could only be done by diminishing the solution loss below what it now is.

We seem therefore to be perfectly safe in saying that *for any condition of which we can conceive the higher the solution loss the lower the fuel economy.*

These considerations demonstrate that the oxygen of the ore instead of being a detriment to the smelting process is an asset of great value, for it alone is available to oxidize the CO formed in the hearth to CO₂, the reaction on which the shaft must depend for the major portion of its heat supply. This is a conception which has as far as I know never been advanced before and is worthy of some reflection.

It is interesting to note the possibility that the greater consumption required for magnetite than for hematite ores under similar conditions may be due to the smaller quantity of oxygen per unit of iron carried by that ore, 0.381 instead of 0.428, and the resulting deficiency of heat accompanies heat requirements per pound of oxygen transferred, greater than those of hematite so that a smaller development coincides with a larger demand. There are, of course, other conditions, the probability of a greater heat requirement in the hearth and of more oxygen to be removed by incandescent carbon in the latter region, and these may readily be the controlling factors. Nevertheless the other consideration is worthy of thought.

There are authentic cases on record in which furnaces have been working badly and apparently too cold in the hearth but not yielding to any of the customary treatments for that condition, which have responded perfectly when the burden was increased. At first sight this seems preposterous and I confess that I formerly listened to such stories with scepticism, but in the light of the above reasoning this becomes more comprehensible; if a furnace, admittedly lightly burdened, and therefore with a surplus of hearth heat passing up into the shaft, received an increase of burden the additional oxygen in the shaft would cause a development of shaft heat more than sufficient for the increased burden and would permit the surplus hearth heat to do its proper work on the additional ore with steadying and generally beneficial results. This is an exaggerated case of the general rule well known to most furnacemen that a heavily burdened furnace generally works better than a lightly burdened one, as long as regular conditions are maintained.

The diagram, Fig. 3, designed in the first place merely to show graphically the results calculated above is believed to have possibilities of wider use. It brings out, as nothing else I have found could do, the direct relationship between the heat requirements of the hearth and of the shaft under different conditions. These have a definite and practically unchanging ratio to one another, for any given set of conditions, and if an increase is to be made in the quantity of either kind of heat produced, it must be accompanied by a proportional increase in the other kind if a corresponding saving is to be made.

The original diagram is drawn to show the effect of

solution loss and that is accordingly made the independent variable. Cases 1, 2a, 3a and 4a, however, also correspond to an increase in the iron per lb. of coke proportional to the decrease in solution loss and as this now becomes the independent variable whose effect we wish to examine I have drawn a separate diagram, Fig. 4, of which abscissae represent a wide range of iron-coke ratios, from 0 to 2:1. Ordinates above and below the zero line represent hearth and shaft heat requirements as before.

The quantities of these for 1.1 lb. of iron per pound of coke (corresponding approximately to 2000 lb. of coke per ton of iron) have been taken from Fig. 3 and lines drawn through each from the zero point, OS and OH. It is evident that the ordinates of these lines for any other iron-coke ratio give the requirements of each kind of heat from each pound of fuel for those conditions (and, of course, those only).

It is evident that if the lines of heat development be outside these lines in both cases or coincide in one and lie outside in the other, we shall have a workable case; but if either line of heat development lies inside the line of corresponding requirements that case is unworkable. I have added to the diagram the line of shaft heat development BAC; the line of hearth heat development with increasing burden, of course, coincides with the line of OH of Fig. 4.

The cases represented by the portion of the line AB outside the line of requirements are workable cases, but those represented by the portion AC inside the requirement line are not workable.

There is one exception to this latter statement to cover the case already described of a surplus of hearth heat utilized to make up a deficiency of shaft heat.

This corresponds to the condition we should have if we increased the hearth heat for cases AC as shown by the dotted line DE as far below the line of hearth requirements as the shaft heat development for those cases is below the shaft requirements.

The slope of the line indicates how impossible it is to go far in this direction.

This corresponds to an equal distortion of both lines of the diagram downward relative to the zero line. The cases so represented are not economical, but are workable, but the cases represented by the distortion of the diagram upward corresponding to the utilization of shaft heat for hearth purposes are not workable, being contrary to the second laws both of thermodynamics and the blast furnace.

There is, of course, a possible limitation to the development of shaft heats which must never be forgotten,

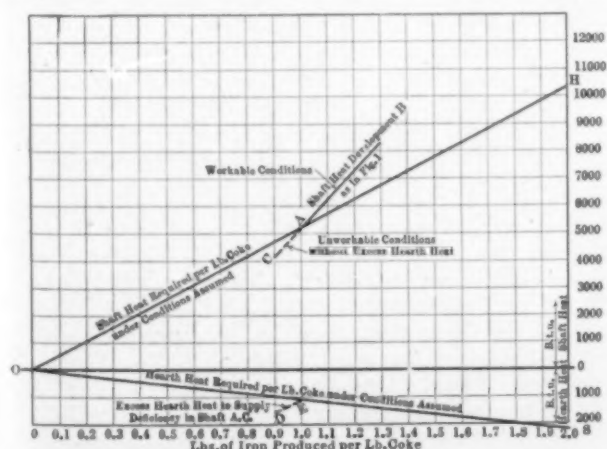


FIG. 4—DIAGRAM SHOWING HEARTH AND SHAFT HEATS REQUIRED PER POUND OF COKE UNDER NORMAL CONDITIONS FOR VARIOUS HEATS OF IRON PRODUCED

though it is further from the furthest limits of practice than we have been accustomed to think, this is the limiting concentration of CO_2 in the presence of ore, irrespective of the presence of carbon, these limits being approximately given above. We must under no circumstances draw our line of shaft heat developed per pound of fuel, beyond the limits set by this limiting ratio; to do so would be to assume that the carbon gas could be oxidized to a degree which is not possible and would lead to a fundamentally incorrect result.

There is no doubt much good work being done with quite high solution loss and some furnace men are inclined to take the stand that high solution loss is not detrimental, but in view of the foregoing demonstration of the facts I believe we are justified in saying that no matter how good work may be done under any given conditions with high solution loss, better could be done without, and the only limit to this statement comes when we reach the limiting concentration of CO , for the given ratio of carbon gas and ore, in the absence of fuel.

It is well to repeat that furnaces which under given conditions could not run for a deficiency of shaft heat may have this deficiency made good by an excess carried over from the hearth. I have run a furnace under such circumstances myself and know it to be true, but it is also true that it is a very uneconomical way to operate and that the hearth heat so utilized is only about one-fifth as valuable as it would be for its proper work in the hearth.

Returning now to Gruner's theorem, remembering that the lower the solution loss the greater the quantity of air required per pound of coke, we may express it tersely as follows: "The lower the solution loss the greater will be the economy of the furnace."

This is the conclusion to which our long and somewhat tiresome investigation has irresistibly led us and we can only pay a tribute of respectful admiration to Gruner for his early discovery of a most important law, whose consequences have been too much neglected. Professor Richards' criticism of it may perhaps be said to have erred in laying too much stress on oxygen-carrying power and too little on the necessity of developing heat which can only be successfully done by utilizing the oxygen-carrying power of the fuel to the maximum possible extent.

Conclusions

It may be well to recapitulate briefly the conclusions reached in this chapter:

For maximum fuel economy there are two principal laws.

First: Each pound of fuel must develop the maximum possible amount of heat.

Second: A certain irreducible proportion of this must be developed above the critical temperature, which is the free-running temperature of the slag.

To accomplish these results we must work along the following lines.

A. Impart as much total oxygen as possible to each unit of carbon before it leaves the top of the furnace.

B. Burn the largest possible proportion of the carbon charged with oxygen from the blast.

C. Heat the blast as hot as possible.

D. Remove the moisture from the blast as fully as possible.

E. Keep the free-running temperature of the slag as low as possible since a decrease in the critical temperature has a greater effect than equal increase in blast temperature.

F. Keep hearth requirements low by keeping down slag volume and avoiding excessive cooling for protective purposes.

G. Keep the actual hearth requirements the same as the theoretical by the use of a system of stock distribution which gives minimum solution loss in the shaft with sufficiently intimate contact of fuel and ore in the hearth.

H. Even following these rules, the hearth heat is generally deficient as compared with the shaft heat and, therefore, except in certain special cases, the heat consumption of the shaft can be increased within reason without much, if any, loss of efficiency by the furnace as a whole.

It has been my endeavor to present here as simply as possible the fundamentals of the thermal action of the blast furnace, but the inter-relations between chemical action and thermal action are so numerous that it is not possible to reduce the subject to short and simple unqualified statements.

In conclusion it may be well to warn those who desire to make thermal calculations for the purpose of investigating possibilities of improvement and the like, never to predict the ultimate consequence of a given charge until they have followed it all the way through to see if it involves any chemical or thermal impossibilities. For such purposes a sheet of the general form used in tables V-VII may be recommended as the outcome of days of effort to record the result of such calculations so that their chemical and thermal effects could be followed to the correct conclusions. But this form does not remove the necessity for a quantity of detailed painstaking and tiresome work, in the accomplishment of such purposes.

Faraday Society Meeting

At the annual general meeting of the Faraday Society, held on Tuesday, Oct. 19 last, at the Institution of Electrical Engineers, the following officers and members of council were elected to serve for the year 1915-16: President, Sir Robert Hadfield; vice-presidents, Prof. K. Birkeland, Bertram Blount, W. R. Bousfield, Prof. F. G. Donnan, Dr. Eugene Haanel, Prof. A. K. Huntington, Dr. T. Martin Lowry; treasurer, Dr. F. Mollwo Perkin; council, W. R. Cooper, Dr. C. H. Desch, Dr. J. A. Harker, Emil Hatschek, Cosmo Johns, Prof. Alfred W. Porter, E. H. Rayner, A. Gordon Salamon, Dr. George Senter, Cav. Magg. E. Stassano.

General Discussion on "The Transformations of Pure Iron"

The professional meeting was devoted to a general discussion on "The Transformations of Pure Iron," and it was presided over by SIR ROBERT HADFIELD, president, who introduced the subject under discussion.

The allotropic theory, while interesting and useful in invoking discussion, had broken down, and although the carbonist point of view had not explained all the difficulties met with, it had gone upon more tangible lines. It was to be hoped that Dr. Oxley's point of view would throw new light on the secrets of the hardening and the magnetization of iron. If it did, the discussion would be the starting point of quite a new line of thought that might bring together the allotropic and the carbonist, and offer them a common and correct explanation of the properties of iron.

Dr. A. E. OXLEY of the University of Sheffield contributed the opening paper to the discussion.

It is now believed by many metallurgists that the A_1 transformation can be satisfactorily explained without assuming allotropic change; but the A_2 transformation is regarded as involving allotropic change.

The crystalline state is one of extreme molecular association (physical aggregates), and if allotropic change is determined merely by the extent of this association, substances will show within a finite temperature interval an infinite variety of allotropic forms, so that the attempts of metallurgists to

show that A_1 involves allotropic change while A_2 does not, need not have been made. To get over the difficulty some metallurgists recognize two definitions of allotropic change: (1) the two-phase (discontinuous) type, (2) the one-phase (continuous) type. The burden of distinguishing between (1) and (2) is here thrown on our experimental refinements, and it is not hopeful that a definite solution can be found.

Defining allotropic change as a difference of atomic structure of the molecule (consistent with the oxygen to ozone transformation), a distinction can be made between it and crystalline grouping (physical aggregates). Allotropic modifications will usually have different crystalline symmetry; but it does not follow that difference of crystalline symmetry necessarily implies allotropic change, for, according to Barlow and Pope, identical molecules can be close packed together in different ways. We must distinguish between the forces holding the molecules together so as to form a definite crystalline structure and those holding the atoms together within the molecule.

From a magnetic and thermal point of view it is concluded that the transition at A_2 involves a re-grouping of the molecules, similar to that which occurs in the ordinary process of crystallization, rather than a rebuilding of the internal structure of the molecule.

Mr. F. C. THOMPSON of Sheffield contributed a paper to the discussion in which he arrived at the following conclusions:

1. Sudden changes in the directions of one or more curves showing the relationship of the physical properties of iron to temperature, indicate with certainty the existence of α , β , γ , and δ iron with change-points at 768° C., 900° C., and 1400° C., while another slight change has been detected magnetically and dilatometrically at about 830° C.

2. The A_2 point in iron taken as typical of all the changes is shown to obey the same laws as hold for other acknowledged allotropic transformations.

3. Magnetic evidence is available that the molecule of β iron is Fe_2 , of γ iron Fe_3 , and of δ iron Fe .

4. A distinct mode of packing of the α , the β and the γ molecules is indicated crystallographically.

5. Thermally it may be shown that changes occurring in iron are of the same nature as those which occur in other cases of allotropic change in metals, e.g. tin and cadmium, and also as in the case of the change from rhombic to monoclinic sulphur.

The author is therefore strongly of the opinion that the transformations in iron are essentially allotropic. At the same time he dissociates himself entirely from the view that to any of the allotropic forms *per se* is the hardness of hardened steel due. Some of the modifications will dissolve carbon as Fe_3C and some to all intents will not; but in this fact alone does the allotropic change bear on the constitution of steel. Whether iron is allotropic or not, it is to the solution of Fe_3C that the characteristic properties of hardened steels must be ascribed. The views of Arnold expressed in 1895 are essentially accepted to-day by the majority of metallographers, and the "hard β iron" to which the strength of hardened steel was due according to the allotropic school is dead.

Prof. PIERRE WEISS of Paris, in a communication which was read to the meeting, referred to his recent work on the magnetization of iron at different temperatures, by which, through adopting newer values for the Curie constant, he has shown that there are at least three transformations in iron: the A_1 , which has a physical character, the A_2 , which presents a discontinuity in the susceptibility, and a third transformation in the β region, pointing to the existence of a β_1 iron with 12 magnetons and a β_2 iron with 10 magnetons in the atom. The latter change is intra-atomic and not—adopting Dr. Oxley's definition—allotropic.

M. H. LE CHATELIER of Paris, also sent a communication to the discussion, in which he deprecated giving a new definition to the word "allotropic." Two allotropic states were merely two clearly defined states of the same composition presenting discontinuity (Benedicks), but coexisting at the same temperature and pressure. Thus fusion and vaporization could be classed as allotropic transformations, and equally so could the A_1 and even the A_2 transformation in iron.

Prof. FREDERICK SODDY of Glasgow, in his communi-

cation, referred to the work of the Braggs on crystal-line structure, which showed that the conception of a molecule has no meaning as applied to a solid, because the atoms of the solid are anchored and do not exist in freely moving groups, i. e. molecules, at all. Oxygen and ozone seem to be the only allotropes that survive gasification. There is little evidence that sulphur and phosphorus, or still less that the metals, behave in an analogous way.

Mr. J. E. STEAD of Middlesbrough, in a written communication, considered that a new definition of allotropy was called for after the work of the chemical crystallographers, and they had to consider whether the new definition was not open to criticism. Could Dr. Oxley explain in his own terms the breaking up of large crystals of iron into small ones when they are heated through the A_c range? There must be a profound internal physical breaking down and rebuilding of the crystalline structure, accompanied by an absorption of heat.

Prof. THOMAS TURNER of Birmingham did not think that to regard changes in iron as more allied to change of physical state than to true allotropy interfered with the view that there are three distinct phases in solid iron, each possessing characteristic properties.

Dr. CECIL H. DESCH of Glasgow discussed the bearing of "dynamic allotropy" and allotropic change as defined in a narrower sense by Honda ("a change in a substance from one phase to another at a definite temperature") on the problem of the transformations in iron. From a purely chemical point of view γ iron and the modification into which it changes on passing through A_r are distinct phases. He agreed with Dr. Stead as to the complete decrystallization at the A_c point. Dr. Oxley's thermal comparisons were open to criticism as the latent heats of fusion were expressed in gram-calories per gram of metal, while the thermal evolutions accompanying allotropic and isomeric changes were given in gram-calories per gram-molecule. The correction considerably reduces the disproportion suggested. The heat evolution accompanying the change from gray to white tin, which is certainly allotropic, is 1133 gram-calories, which is less than the latent heat. Moreover, the evolution of heat in iron, apart from the necessary correction, was too low as given by Dr. Oxley, for it should include the whole area of the peak in the inverse rate in the derived differential curve. As corrected it would approximate to that for tin. He therefore concluded that there was no reason for removing the $\gamma \rightarrow \alpha$ and $\gamma \rightarrow \beta$ changes from the category of allotropic transformations.

Mr. A. McCANCE of Glasgow laid down the condition that a definition must be independent of a theory, and Dr. Oxley's was not so. He also dealt with the modern conception of the molecule, touched on by Professor Soddy, and on the definite crystallization change in iron at the A_c point emphasized by Dr. Stead. This was something more than mere closeness of packing.

Mr. T. G. ELLIOTT of Sheffield thought that Dr. Oxley's test of allotropy, involving the withdrawal of restraining forces, demanded a hypothetical condition in the material to be tested. Could crystals be built up of distorted molecules?

The President pointed out that a knowledge of the transformations of iron was essential for the successful production of hardened steel. He mentioned the interesting fact that many of the iron alloys at the temperature of liquid air attained a tenacity of 160 tons per square inch.

Prof. H. C. H. CARPENTER thought it preferable to say that iron existed in one phase below and in another phase above 900 deg. C. It was not certain that the molecule of iron was polyatomic. Judgment must be

suspended until Professor Bragg had examined a well-formed crystal with the x-ray spectrometer. He did not see how cooling through A_c could lead from a more open to a closer packed cubic system, seeing that there was an expansion during the transformation. Finally, he exhibited slides illustrating the remarkable crystallographic changes that occurred when iron of exceptional purity was heated for some time at 915 deg. C. and then allowed to cool. Whether allotropic or not, very profound physical changes took place at the A_c point.

Dr. J. A. HARKER expressed his surprise that so little work had been done in the determination of the thermal constants of pure iron. He outlined a possible method for the determination of the latent heat of fusion of pure iron.

The President offered to defray the cost of the work if it could be carried out at the National Physical Laboratory.

Prof. J. W. NICHOLSON thought the idea of a sort of atomic allotropy the really new thing in Dr. Oxley's conceptions. The fact was there were many varieties of allotropy, which needed subdivision into several groups. Bragg's work might be used in support of Dr. Oxley's hypothesis.

Prof. ALFRED W. PORTER could not understand how Dr. Oxley's definition could receive practical application, as the only method of removing the restraining forces from the molecules of a substance was by vaporizing it.

Dr. T. MARTIN LOWRY protested against altering Berzelius' definition of allotropy, which had been in use for seventy years. If a new definition was required it should be attached to a new word. He was content to think that different modifications of iron might be made up of the same molecules arranged in different ways, but in the case of an element, such as sulphur, this would still be allotropy. Dr. Oxley's thermal data were unconvincing. He might have selected changes, such as the inter-conversion of certain isomerides, in which the thermal changes were small.

Dr. E. K. RIDEAL referred to Partington's work on the vapor pressure of copper sulphate crystals, carried out by the method of passing dry air over the crystals. The differences between these values and those obtained by the static method might be explained by taking into consideration the space lattices of the crystals. Similar work might be done in the case of iron.

Dr. J. R. PARTINGTON pointed out that the atomicity of metals in the solid space could be determined from measurements of specific heat. Nernst found that nearly all the metals were monatomic.

Dr. H. BURNS asked Dr. Oxley why he had ignored Weiss's recent work, which proved that iron was polyatomic and that β iron differed from γ iron in atomicity.

Dr. A. E. OXLEY in reply said that Bragg's work was not necessarily opposed to his views, because Bragg himself agreed that in the case of complex molecules it was possible to draw a boundary round a certain group of atoms in a crystal and say that they belonged to a particular molecule.

The linear expansion found by Benedicks to occur in iron when it cools through the A_c point was not opposed to a closer packing of the molecules in the direction of spontaneous magnetization.

With regard to the definition of allotropy, it was obvious that examples of the type of oxygen and ozone should not be classed with cases which could be explained by loose molecular association.

His definition of allotropy was theoretical to a large extent, but the idea could be followed by considering the case of ozone and oxygen. In the crystalline state these substances were different from each other; on removing the restraining forces by fusion or vaporization, they

were still more different from each other and were therefore allotropes.

Weiss's work on the magnetic properties of iron was no proof either of the atomicity of the different kinds of iron or of the magneton theory, as he assumed the truth of one to prove the other.

A paper on "The Transference of Electricity by Colloidal Particles," by F. POWIS of Leeds, was read by title.

An attempt is made to calculate the charge carried by the particles of a colloidal solution produced by sparking, (1) from a modification of Stokes's formula, (2) from the increase in conductivity on making the solution. Although the data available for the calculations are not very satisfactory, the second method gives a value much greater than the first. The author believes this is because the particles are not like the ions of an electrolyte solution, but that anions and cations are absorbed on their surface in such a way that the concentration of each gradually decreases with increasing distance from the particle, until each finally becomes equal to that in the bulk of the surrounding medium; the ions are so arranged, however, that with a negative colloid the layers nearer the particle contain an excess of anions, and those further away an excess of cations, whilst with a positive colloid this is reversed.

A paper on "Electrolysis of Nitric Acid, Sulphuric Acid and Orthophosphoric Acid, Using a Gold Anode," by F. H. JEFFERY, of the University Chemical Laboratory, Cambridge, was then presented.

(A) The platinum cathode was inclosed in a porous pot and the acid used for catholyte was of same concentration as that used for anolyte. Acids of various concentrations were obtained by diluting conc. nitric acid Δ 1.42 with distilled water. The experiments were performed at the temperature of the laboratory, 15° to 20° C. In all cases the soluble gold compounds formed contained the gold as complex anion; no gold was deposited on the cathode.

In an acid formed from 1 c.c. conc. HNO_3 to 1 c.c. water soluble compounds were alone formed. The gold went into solution, forming aurinitric acid, $\text{HAu}(\text{NO}_3)_2$, and an aurous compound, perhaps $\text{HAu}(\text{NO}_3)$, which deposited gold on being left in a closed flask. The anolyte was hydrolysed by water, giving a mixture of hydrated auric and aurous oxides such that $\text{Au}_2\text{O}/\text{Au}_2\text{O}_3 = 0.02$. The anolyte changed in color from deep olive-green to dark yellow-brown on prolonged electrolysis, owing to changes in the ionic dissociation of the compounds.

In acids of concentration ranging from that corresponding to 1 c.c. conc. acid to 2 c.c. water to that corresponding to 1 c.c. conc. acid to 20 c.c. water there were solid products formed at the anode. These were mixtures of hydrated auric oxide and aurous oxide for the more concentrated acids and hydrated auric oxide alone for the less concentrated acids; for 1 c.c. conc. acid to 2 c.c. water, $\text{Au}_2\text{O}/\text{Au}_2\text{O}_3 = 0.07$; for 1 c.c. conc. acid to 4 c.c. water, $\text{Au}_2\text{O}/\text{Au}_2\text{O}_3 = 0.05$; for 1 c.c. conc. acid to 10 c.c. water, hydrated Au_2O_3 is alone formed; the same is true for 1 c.c. conc. acid to 20 c.c. water.

The current density did not appear to determine the composition of the compounds formed at the anode.

In the case of the dilute acids, such as 1 c.c. conc. acid to 10 c.c. water, undissociated ammonium nitrate diffused into the anolyte from the catholyte, and if the concentration of the ammonium salt was allowed to rise, compounds were formed at the anode which were explosive when heated; apparently complex cations containing gold were formed, giving a deposit of gold on the cathode.

In all cases the solid compounds gave a trace of nitric acid on heating, even when they had been previously stirred with water for weeks. This was probably due to the presence of a small quantity of a basic nitrate.

(B) In an acid formed from 1 c.c. conc. H_2SO_4 Δ 1.84 to 1 c.c. water soluble compounds were formed containing the gold as complex anion; finely divided gold was formed throughout the anolyte. The soluble compounds were at first green, becoming dark brown on prolonged electrolysis. No gold was deposited on the cathode except at the end of a long electrolysis, and then only in very small quantity. The anode potential remained constant throughout the electrolysis. When the anolyte was hydrolysed a solid was obtained consisting principally of hydrated auric oxide and aurous oxide, but it was impossible to free it from a trace of basic sulphate. The gold went into solution, forming both aurous and auric compounds. In an acid formed from 1 c.c. conc. H_2SO_4 to 7 c.c. water a solid was formed at

the anode, which was a mixture of aurous oxide and hydrated auric oxide with a trace of basic sulphate. No free gold was formed in the anolyte.

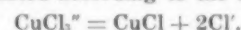
(C) The quantity of soluble gold compound formed in the anolyte was very small, and the gold was present as anion alone. A solid was formed at the anode consisting of hydrated auric oxide and aurous oxide, but even after stirring with water for twenty-four weeks it could not be freed from a trace of some compound giving H_3PO_4 with water.

In an anolyte containing 15 per cent H_3PO_4 by weight the solid product corresponded to $\text{Au}_2\text{O}/\text{Au}_2\text{O}_3 = 0.07$, and in one containing 20 per cent H_3PO_4 to $\text{Au}_2\text{O}/\text{Au}_2\text{O}_3 = 0.09$.

A paper on "Electrolysis of Concentrated Hydrochloric Acid Using a Copper Anode," by F. H. JEFFERY, was then presented.

The platinum cathode was inclosed in a porous pot, and all experiments were performed in nitrogen or carbon dioxide.

The copper dissolved in the cuprous condition and as complex anion alone, there being no deposit of copper on the cathode. No chlorine was evolved at the anode. The anion appears to be CuCl_2^- , and if the electrolysis was prolonged CuCl was precipitated according to the relation.



If a platinum cathode in dilute hydrochloric acid inclosed in a porous pot was used with an anolyte of KCl solution of concentration 30 grams KCl per 100 c.c. water, crystals of K_2CuCl_4 were obtained from the anolyte, the copper went into solution entirely in the cuprous condition, and no chlorine was evolved at the anode. No copper was deposited at the cathode. As before, cuprous chloride was precipitated after the electrolysis had proceeded for a considerable time.

"The Thermal Decomposition of Hydrogen Peroxide in Aqueous Solution" was the title of a preliminary note by WILLIAM CLAYTON, of the Muspratt Laboratory of Physical and Electro-Chemistry of The University of Liverpool.

1. The rate of thermal decomposition of aqueous solutions of hydrogen peroxide is extremely sensitive toward extraneous organic matter in the colloidal state. Mechanical factors, such as volatility and the presence or absence of stirring, do not exercise an appreciable influence.

2. The chief factor in the decomposition has been shown to be the degree of purity of the water. Thus in tap-water the rate of decomposition is fully fifty times that in the purest specimen of water we have yet prepared.

3. In the light of these results, previous work upon the thermal decomposition of H_2O_2 , especially the comprehensive research of Lemoine, must be considered as of doubtful value, as no special precautions appear to have been taken in regard to the solvent.

4. In view of the marked effect produced by the solvent it remains an open question as to whether the surface of the vessel exerts an appreciable effect or not; it is possible that effects previously attributed to the surface may have been due to slight variations in the organic-matter content of the solvent.

The Burdett Oxygen Company, with main office at Chicago, has opened a station at Fort Worth, Tex., this being the ninth station of this company.

A Rennerfelt electric steel furnace has been installed in the new plant of the Old Dominion Iron & Nail Works Co., Richmond, Va. This is the second of these furnaces to be used by this company.

The complete report of the Selby Smelter Commission, by J. A. Holmes, Edward C. Franklin and Ralph A. Gould, issued as *Bulletin* 98 of the Bureau of Mines, is one of the most interesting and valuable documents of the kind yet published. Methods of procedure in analyzing gases are given in detail, and supplemented by tabulated data and conclusions. Illustrations in color show the effect of sulphur dioxide on vegetation of various kinds. A bibliography is appended, prepared by the Chemists' Club Library, on the effect of sulphur dioxide on vegetable and animal life.

Extraction of Radium, Uranium and Vanadium from Carnotite

From an official advance notice on Bulletin 104 of the Bureau of Mines, entitled "Extraction and Recovery of Radium, Uranium and Vanadium, by Charles L. Parsons, R. B. Moore, S. C. Lind and O. C. Schaefer, we take the following interesting information:

This bulletin gives the results of the coöperative work with the National Radium Institute, which has been mining carnotite claims in the Paradox Valley and studying the concentration of low-grade ores at that point. The present bulletin, however, describes only the methods of extracting radium from carnotite ore as carried out in the plant at Denver.

The methods devised have proved highly successful. They depend essentially upon the fact that strong, hot nitric acid has a high solubility coefficient for radium and barium sulphates. This enables the carnotite ores to be treated directly with hot nitric acid, removing the values therefrom at a single operation. The method follows in brief:

The carnotite ore pulverized to 20 mesh is treated in a special earthenware leaching pot with 38 per cent nitric acid; 500 lb. of ore being used to 121 lb. of 100 per cent HNO_3 . The acid is brought near to boiling by means of steam passed through a glass tube and the ore gradually stirred in. Heating is continued for 15 minutes when the acid is filtered from the ore in a stoneware filter. This is followed by a second treatment in the same leaching pot with somewhat weaker hot nitric acid, after which the whole is washed with hot water. Nearly all of the uranium, about 50 per cent of the vanadium and over 90 per cent of the radium are carried into solution by this method and separated from the bulky residues, which are then discarded. The acid solution is nearly neutralized with sodium hydroxide, barium chloride and sulphuric acid added in proper quantities and held in settling tanks with conical bottoms for three days to settle out the radium barium sulphate. The supernatant liquid is then syphoned into an excess of boiling sodium carbonate solution to separate the uranium and vanadium from iron, aluminium and calcium. The radium barium sulphate left in the tank is run on to a stoneware filter, filtered, washed and dried, the washings being also added to the sodium carbonate solution already mentioned.

The soluble sodium uranyl carbonate and the sodium vanadate are filtered from the iron calcium precipitate in filter presses and run into uranium precipitation tanks. The sodium carbonate is then nearly neutralized with nitric acid and sodium hydroxide added to complete precipitation of the uranium as sodium uranate. The filtrate containing the vanadium is carefully neutralized with nitric acid and iron sulphate added to precipitate vanadium as iron vanadate. Both the sodium uranate and the iron vanadate are separated from their solutions by means of filter presses. The filtrate from the iron vanadate consists almost wholly of a solution of sodium nitrate containing, of course, a small amount of impurity. This filtrate is evaporated, sodium nitrate recovered and used again for the manufacture of nitric acid. The radium barium sulphate, without further treatment, is reduced in large graphite crucibles by charcoal, a very efficient conversion (90 to 95 per cent) into barium radium sulphide being obtained. The sulphides are dissolved in hydrochloric acid and the residue of unchanged sulphates re-treated.

The chloride solutions are crystallized in the plant in silica-lined kettles, care being taken to keep the solutions acid with hydrochloric acid as the separation of radium from barium is much more rapid, under these

conditions. The concentrated chlorides carrying from 4 to 10 mgs. of radium per kilogram are taken to the laboratory, filtered from any insoluble impurities and crystallized again in strong acid solution until the bulk has been reduced to a small volume, when they are converted into bromides. This is done after first neutralizing with ammonia and precipitating with hydrogen sulphide to remove lead, which always accumulates and which is not precipitated by hydrochloric acid from strong barium chloride solutions. After removal of the lead the barium and radium are converted into carbonates by the addition of ammonium carbonate, washed and dissolved in hydrobromic acid. From this point on crystallization takes place in pure quartz dishes in solution strongly acid with hydrobromic acid.

The fractional crystallization of radium from the original chlorides to the finished product is neither tedious nor difficult but takes place rapidly when acid solutions are used and proper apparatus is available which will withstand their action. The efficiency of the process is high.

In connection with the radium plant, a nitric acid plant has been erected which produces over 5000 lb. of nitric acid per day. Owing to the recovery of sodium nitrate the cost of the nitric acid used has been very low, averaging under the present cost for nitrate slightly less than $2\frac{1}{2}$ cents per pound. To Sept. 1 4774 mgs. of radium were produced in the form of sulfates and 1947.5 mgs. of element had been delivered in the form of bromide. Deliveries are continuing at the rate of 300 to 400 mgs. per month.

The cost of radium element figured on the basis of all the radium produced to Aug. 1, which includes the higher costs of the earlier operations, was \$37,599 per gram of radium element. This includes the cost of ore, 20 per cent plant amortization, Bureau of Mines coöperation, and operating costs of all kinds, including repairs. The bulletin gives full details of operation, including detailed drawings of the plant and halftone illustrations of the plant and equipment. The radium produced is being used in the Howard A. Kelly Sanatorium at Baltimore and the General Memorial Hospital, New York City, for the treatment of cancer and other malignant growths. It is not for sale.

General Meeting of the German Bunsen Society for Applied Chemistry

The twenty-second general meeting of the German Bunsen Society for Applied Physical Chemistry was held in Berlin on Oct. 17 and 18, 1915. The president, Dr. Hans Goldschmidt of Essen-Ruhr, presided at the meeting. He pointed out in his speech of welcome that while most other societies were simply transacting business matters at their general meetings on account of the war, the Bunsen Society was continuing its work as in peaceful times. He thanked Professor Nernst, in whose institution the meeting was held, mentioned those who had fallen in the war and referred to the death of Professor Hittorf, whose noble personality he sketched in some detail. It was decided to leave the selection of the next meeting place to the executive committee. An invitation to come to Karlsruhe has already been extended.

A great variety of subjects, both practical and theoretical, were taken up in the papers presented.

Electrochemical Processes

A paper on the "Electrolytic Preparation of Perborate" was presented by Prof. K. Arndt of Charlottenburg. This paper described a process of the author, in which a borax soda solution is electrolyzed.

Sodium perborate $\text{NaBO}_3 + 4\text{H}_2\text{O}$ is a well-known oxygen bleaching agent. It was first produced by Tanatar in 1898 by combination of sodium metaborate with hydrogen peroxide. Sodium peroxide has later been used in large-scale manufacture. In 1898 a communication from Tanatar stated that he had obtained perborate by electrolysis of a concentrated borax solution. In 1910 M. A. Pouzenc obtained a French patent on the electrolytic production of perborate in a diaphragm cell, using a cooled orthoborate solution and rapidly circulating same. In repeating these experiments Polock could only obtain a very small output with strongly concentrated solutions and could not duplicate Pouzenc's results.

Professor Arndt's process consists in electrolyzing a solution made up of 45 grams borax and 120 grams sodium carbonate to a liter of water. In the laboratory he used a platinum gauze anode and a water-cooled tin-tube cathode; the latter is arranged in zig zag form on both sides of the anode, the distance between anode and cathode being 4 mm. At 20 amp. and 6 volts a temperature of 17-18 deg. C was maintained. The strong evolution of gas helped to keep the electrolyte in motion. The loss due to cathodic reduction was small. When the content of the bath in active oxygen is high enough the current is interrupted. After some time sodium perborate will crystallize out and can be removed and washed, forming a pure and stable product. The mother liquor may be again electrolyzed.

A paper on "Aluminium Nitride" was presented by Prof. Paul Askenasy of Karlsruhe. He mentioned the great interest which attached to the discovery of the reaction between an alumina-carbon mixture and nitrogen, in which aluminium nitride is formed at 1800 deg. C. Professor Askenasy recited the work of Serpek, the Badische Anilin and Soda Fabrik, Giuliani Brothers, and the researches of Dr. W. Fraenkel and Prof. F. Fichter. Aluminium nitride, when treated with water or alkali is converted into ammonia and alumina, and a tremendous field awaits the successful execution of such a process. The author reports on the continued researches of Dr. Walther Fraenkel, with special reference to the effect of different kinds of carbon on the reaction velocity. The researches show that acetylene black was especially capable of helping the reaction. Next in order were charcoal and graphite. With coke the reaction proceeds more slowly. The alkali content of the charcoal accelerates the reaction. When larger additions of alkali are intentionally made, the acceleration of the speed of reaction is remarkable, especially when coke is used.

Temperature Scale and Atomic Weights

A paper on the "Temperature Scale of the Reichsanstalt and the Standardization of Temperature Measurements," was presented by Geheimrat Professor Holborn of Berlin. This paper dealt with the use of gases in thermometry and pointed out that different results had been obtained with different gases, whereas it had been thought by Regnault that it was immaterial which gas was used. Differences exist already between hydrogen and nitrogen thermometers between 0 and 100 deg. which influence the measurements. The temperature scale was founded on hydrogen because this gave the lowest zero point. The International Commission of Weights and Measures adopted the hydrogen scale in 1887 between 0 and 100 deg. for the special purpose of calibrating international units of length and weight. It has also been used by the Physikalische Technische Reichsanstalt for thermometer testing. Attempts to use the hydrogen scale

above 100 deg. have met with difficulties because the hydrogen attacked the glass container and penetrated metal containers. Nitrogen and air have been tried. The result has been a number of different scales which do not agree so that it was always necessary in the literature to state what kind of a scale was used. At the boiling point of sulphur there exists already a difference of several tenths of a degree.

In order to remedy these differences the Reichsanstalt made the proposal in 1911 to refer all results to the thermodynamic scale, the variations of which from other scales were known. A second proposal was made to make a practical scale which would be as near as possible to the thermodynamic scale and which would be determined by the already fixed points. Besides the fixed points the practical scale should be formed by the platinum thermometer in the range from 40 to 450 deg. C. (boiling point of sulphur). In this range the platinum thermometer forms a very simple scale if 0 deg., 100 deg. and the melting point of sulphur are fixed. It is not necessary to have especially very pure platinum. It is noteworthy that no serious differences occur between this scale and the old hydrogen scale. It is important, however, what value to use for the melting point of sulphur. Results vary between 444.54 and 444.56. The Reichsanstalt has adopted 444.55. Definite fixed points in the new scale are the melting points of Hg, Sn, Zn, Cd, and the boiling points of naphthalene and benzol. From the boiling point of sulphur to 1000 deg. any desired scale may be used. For higher temperatures radiation pyrometry comes in.

In the temperature range below 0 deg. C. many measurements have been made lately with hydrogen and helium thermometers and a close agreement has been found. It would be desirable to have melting points in this range because they are better standards than boiling points.

A paper on the "Atomic Weights of Thorium and Ionium" was presented by Prof. Otto Hönigschmid of Prag, Austria, in which the author gives the results of two determinations made in the atomic weight of thorium. On account of the isotropy of thorium and ionium and their occurrence together in uranium ores, the author concludes that thorium separated from uranium-containing minerals is a mixture of thorium and ionium and must have a lower atomic weight than ordinary thorium which has been isolated from minerals free of uranium. By a method using proportions between thorium bromide, silver bromide and silver, the value found for pure thorium from monazite sand was 232.151 ± 0.015 from 24 determinations. This value is 0.25 lower than the formerly determined international weight of thorium. A thorium preparation from St. Joachimsthal pitch blende was also treated to produce thorium oxide and examined spectroscopically. It was found to be identical chemically and spectroscopically with the purest thorium from monazite sand. The average of six determinations on the atomic weight gave 231.507 ± 0.012 , which is 0.65 lower than ordinary thorium. The bromide of this thorium isolated from uranium ore appears intensively violet in the dark, similar to radium bromide and gives off strong alpha rays, differing in both these properties from common thorium bromide. The author says the differences in the atomic weights are due to the presence of ionium. The ionium content is figured as 30 per cent.

Other Papers

A paper on the "Reaction Between Ferrous Oxide and Carbon and Carbon Monoxide and Iron," by Dr.

V. Falcke, of Leipzig, dealt with the author's re-determination of the equilibrium between CO and Fe and C and FeO.

A paper on the "Combining of Chlorine and Hydrogen" was presented by Professor Bodenstein of Hanover, dealing with the influence of light, heat and alpha radium rays and oxygen, on the reaction velocity, as investigated by Drs. Taylor and Dux. Their work was interrupted by the war, but their results are given as far as obtained.

Two papers on analysis were presented, one by Prof. W. Böttger of Leipzig, on the determination of small amounts of mercury salts in weak solutions, and a paper on metallic calcium and its application in gas analysis by Professor Sieverts of Leipzig. Prof. Walter Nernst demonstrated the application of alternating currents to bridge measurements, for instance, for determining dielectric constants. By the use of the loud-speaking Siemens telephone and inductor of the Telefunken-Gesellschaft a loud sounding system can be arranged suitable for demonstration purposes. The physical chemistry of food was taken up in a paper by Geheimrat Prof. Theodor Paul of Munich, who described the use of carbonate of lime for neutralizing the acid in wine. A paper by Prof. G. Meyer of Freiburg described the results of Dr. H. Stocker on the surface tension of pure water and salt solutions. The double refraction of vanadium pentoxide was discussed in a paper by Prof. H. Freundlich of Braunschweig. The reaction velocity of ideal gases was discussed in a paper by Prof. Max Trautz, of Heidelberg. A paper on passivity phenomena in the anodic production of halogens and the cathodic deposition of iron metals in solution was presented by Hofrat Prof. F. Foerster of Dresden. Colloidal gold was discussed in a paper by Prof. Richard Zsigmondy, and Prof. H. Goldschmidt of Kristiania, presented a paper on the alcoholization of salts. The darkness of ink on paper was discussed in a paper by Dr. W. Mecklenburg, of Berlin-Lichterfelde. A paper on the parallelism between electric light effect and Volta effect was presented by Prof. Krüger of Danzig. A paper on capacity of liquid insulators was presented by Professor Holde of Berlin. A paper on the gas content of the Taunus rocks and its relation to the springs of Wiesbaden was presented by Prof. F. Henrich.

The General Chemical Co. has just awarded to John W. Ferguson Co., engineers and contractors, Paterson and New York City, a contract for the construction of a manufacturing building at their Hudson River Works, Shadyside, N. J., across the Hudson River from New York City. This building will be two stories high 54 ft. by 55 ft. A 20-ft. by 20-ft. sq. tower rises from one corner, 30 ft. above the main building.

The Williams Apparatus Co. of Watertown, N. Y., has been formed to take care of the increased business of the Williams improved gas apparatus, as well as other high-grade specialties which the company is bringing out. The need of a compact, portable instrument by which an accurate gas analysis could be made quickly has been felt for some time and the popularity which the Williams apparatus has attained in a comparatively short time is an indication that it meets a real want. The Williams Apparatus Co. has expert glass-blowing and repair facilities both for the manufacture of its own products and special service of its patrons. In view of the present European war conditions these facilities are of particular timely value.

The tin smelter erected by the American Smelting & Refining Co. at Maurer, N. J., to smelt Bolivian tin ores, will be ready to operate in January.

The Character and Extent of Atmospheric Pollution in English and Scotch Towns

With Notes Upon a New Type of Recording Actinometer

BY JOHN B. C. KERSHAW

The issues of METALLURGICAL & CHEMICAL ENGINEERING for June and November, 1913, contained a detailed account by the present writer of the aims and work of the London Committee for the Investigation of Atmospheric Pollution, together with an illustrated description of the standard type of soot and dust collecting gage.

The method depends upon the use of an enlarged type of rain gage for the collection of the whole of the monthly rainfall at selected localities in each town. The soluble and insoluble impurities contained in the collected rainwater are then separated and are estimated by chemical methods. In some towns only one gage is installed, but in London, Glasgow, Birmingham, Sheffield and Manchester there are several gages placed at different points. Manchester, indeed, has ten gages in use in different parts of the city and its surrounding districts, and is also undertaking another investigation which will be referred to later.

The observations have now been carried out in sixteen English and Scotch towns for twelve months, and valuable information has been collected bearing upon the amount and character of the pollution existing in the air of the larger industrial cities. An official report upon the whole of the collected figures will be published by the committee at a later date, but the present article represents the writer's analysis of some of the figures and the conclusions drawn from them. The importance of knowledge of the local conditions existing in each town is shown by the comments on the Liverpool results.

RESULTS IN TEN ENGLISH TOWNS FOR THE SIX WINTER MONTHS OF 1914-1915

Table I contains a summary of the more important figures for ten English towns covering the six winter months, October to March, 1914-1915. It will be seen that Oldham occupies the place at the head of the table, with a soot and dust fall in the six months of 532 tons per square mile, equivalent to 1064 tons per square mile per annum. Birmingham (central) comes next, with a fall of 382 tons in the six months, while Bolton, Sheffield, Liverpool, Newcastle, Manchester and London follow in the order named.

TABLE I—THE SOOT AND DUST FALL OF ENGLISH TOWNS
FALL OF SOLID MATTER, OCTOBER, 1914, TO MARCH, 1915.
Tons per square mile.

Name of Town or City	Total Solids	Tar, Soot and Ash
Oldham	532	364
Birmingham (Central)	382	252
Bolton	346	131
Sheffield (Attercliffe)	321	193
Liverpool	286	167
Newcastle	265	156
Manchester (Technical School)	263	156
London (Golden-Lane)	249	128
York	158	78
Malvern	32	5.88

York and Malvern occupy, as might be expected, the places of honor at the bottom of the table, with total soot and dust falls of 158 and 32 tons respectively. The latter figure is only one-eleventh that of Bolton and only one-seventeenth that of Oldham, and it shows what great scope exists for improvement in the atmospheric conditions of the Lancashire manufacturing towns.

London occupies a comparatively good position, ranking below all the Lancashire and other manufacturing towns of the north in the cleanliness of its atmosphere.

Examination of the deposit shows that the insoluble solid matter that has fallen during the winter months in the ten towns dealt with is composed of tar, solid car-

bonaceous particles and ash, and that the relative proportions of these three constituents do not vary very considerably in the different towns. Thus at Oldham, the insoluble solid deposit contained 1.5 per cent of tar, 29 per cent of carbonaceous matter, and 69 per cent of ash, while at York the percentages were 2, 30 and 68.

As a general rule, the percentage of ash is highest and the percentage of tar and soot lowest in manufacturing districts, since when fuel is burnt under boilers or in furnaces there is a tendency for the smaller particles of unconsumed fuel to be carried up the chimney and to be discharged as fine ash into the atmosphere. The temperature of the furnace is (or ought to be) sufficiently high to consume all the hydrocarbon gases and to prevent the formation of smoke and soot. In residential districts with old-fashioned grates, the opposite conditions prevail, and the proportion of tar and carbonaceous matter present in the smoke is generally higher than in factory districts.

The figures showing the percentage composition of the solid deposit collected by the standard gages in ten English towns and cities are gathered together in Table II, and on the whole support this view.

TABLE II—THE SOOT AND DUST FALL OF ENGLISH TOWNS. PROPORTIONS OF INSOLUBLE SOLIDS, OCTOBER, 1914, TO MARCH, 1915.

Name of Town or City	Tar		Carbon		Ash	
	Weight in tons	Per cent of total fall	Weight in tons	Per cent of total fall	Weight in tons	Per cent of total fall
Oldham	5.57	1.5	109	29	249	69
Birmingham (Central)	3.20	1.3	67	26	182	72
Sheffield (Attercliffe)	2.46	1.3	61	32	129	66
Liverpool	4.37	2.6	35	21	128	76
Newcastle	2.05	1.3	59	37	96	61
Manchester (Tech. School)	1.80	1.1	51	33	103	66
Bolton	1.63	1.2	31	24	99	74
London (Golden-Lane)	1.15	.90	49	38	78	61
York	1.60	2.0	24	30	53	68
Malvern	0.05	1.0	2	34	3.83	65

The average percentage ash fall in the five typical manufacturing towns, Oldham, Birmingham, Sheffield,

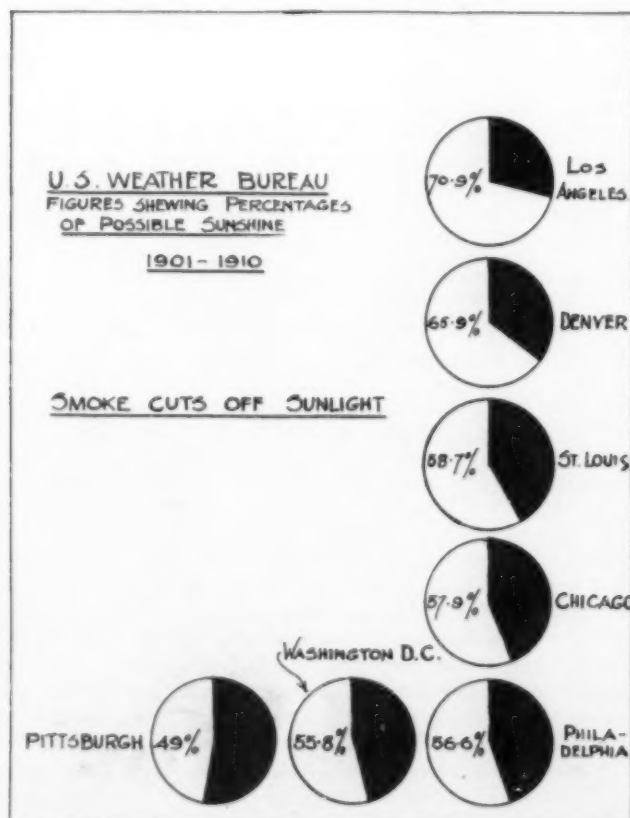


FIG. 1—SUNSHINE DIAGRAMS FOR SEVEN AMERICAN CITIES

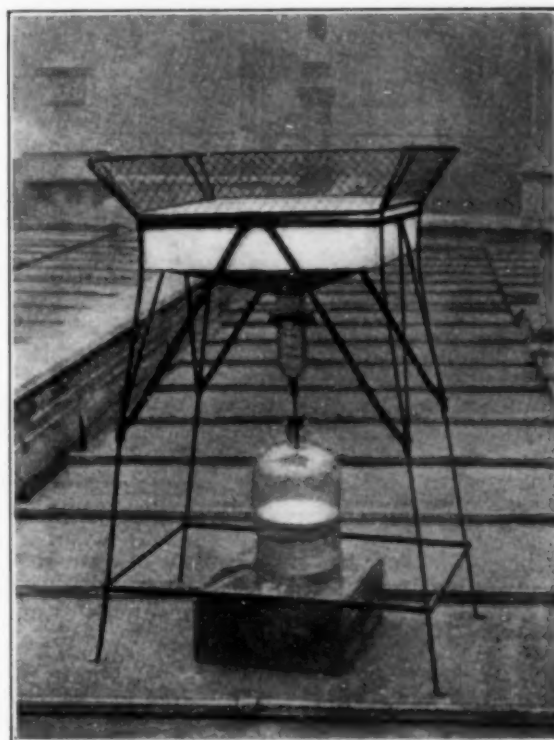


FIG. 2—THE ORIGINAL SOOT AND DUST GAGE USED FOR THE LANCET EXPERIMENTS IN LONDON, 1910-1911

Manchester and Bolton, is 69 per cent, as compared with 64 per cent for the four towns which may be classed as seaports or as residential in character, namely, London, Newcastle, York and Malvern. The tarry and carbonaceous constituents of the soot and dust fall in the four latter towns amounted to 36 per cent of the whole deposit, as compared with 31 per cent for the five manufacturing towns.

Liverpool seems to occupy an isolated position in this respect, for the percentage of solid matter in its soot and dust fall was higher than that of the manufacturing towns and its percentage of carbonaceous matter extremely low. This peculiarity is most probably due to the fact that in hot weather, under certain conditions of the wind and tide, a large quantity of fine sand is carried over the city from the sandy shores that lie on its north and northwest side. This fine sand falls by its own weight or remains suspended in the atmosphere until carried down with the rain, and tends to increase the incombustible solid portion of the deposit.

RESULTS IN SIX SCOTTISH TOWNS FOR THE WINTER MONTHS, 1914-1915

Turning now to a consideration of the returns that have been received from Scotland, we find that only six towns have carried on the observations during the winter of 1914-1915. These observations were interfered with greatly by frost and by breakage of the collecting bottles, and therefore they do not cover the whole period, nor are they strictly comparable with the English results.

The figures, so far as they are available, have been calculated out as tons per square mile, and are gathered together in Table III.

Assuming that the soot and dust fall for the shorter periods would increase proportionately for the whole of the winter, we find that the relative positions of these five towns are Glasgow, Paisley, Greenock, Stirling and Leith. Glasgow (Blythswood Square) possesses a total soot and dust fall of 327 tons, and ranks equal to Shef-

field (Attercliffe) in Table I, while Leith has a total fall of 147 tons in the six winter months, and would be placed below York and Exeter in Table I. The observations made by Chief Inspector Fyfe in the winter months of 1910-1911 gave the same relative positions for the four towns—Glasgow, Paisley, Greenock and Stirling—and are thus confirmed.

TABLE III—FALL OF SOLID MATTER IN SIX SCOTCH TOWNS DURING THE WINTER MONTHS OF 1914-1915.

Name of Town or City	Tons per square mile		Remarks
	Total Solids	Tar, Soot and Ash	
Glasgow (Blythswood Square)	109	49	Two months
Glasgow (average of 7 stations)	79	28	Two months
Greenock	116	55	Three months
Stirling	84	38	Three months
Paisley	174	96	Four months
Leith	98	55	Four months

SUMMER AND WINTER RESULTS COMPARED

In view of the greater amount of fuel burnt in all large towns during the winter months of the year, and of the longer hours of darkness, during which it is possible for lazy or negligent firemen in factories to emit thick black smoke without being caught or fined, the soot and dust fall might be expected to be much heavier in the winter than in summer, and the observations confirm this expectation.

TABLE IV—THE SOOT AND DUST FALL OF ENGLISH TOWNS THE TOTAL FALL OF SOLID MATTER IN THE WINTER AND SUMMER MONTHS COMPARED.

Town	Tons per square mile in six months		
	Summer Months April to September, 1914	Winter Months October, 1914, to March, 1915	Percentage Increase or Decrease
Liverpool	299	286	- 5
Newcastle	209	265	+ 27
London (Golden-lane)	145	249	+ 72
York	120	158	+ 32
Malvern	34	32	- 7

Table IV contains a summary of the results obtained by adding together the soot and dust fall in several towns for the six summer months of 1914, and comparing the aggregate with the fall during the six winter months.

Only five towns had completed twelve months' observations in last March, and three of these, namely, Newcastle, London and York, showed a considerable

increase in the aggregate soot and dust fall for the six winter months of the year, the increase ranging from 27 per cent in Newcastle up to 72 per cent in London.

Liverpool provides an exception to the general rule, the winter soot and dust fall being lower than the summer one. This unusual feature of the Liverpool returns is due probably to the same cause as that noted earlier, namely, the fine drift sand which adds to the incombustible solid matter of the Liverpool deposit. This drift sand is carried the greatest distance during the summer and early autumn gales, when the hot sun has dried the surface sand on the shores of the Mersey estuary. In the winter time the sand is never sufficiently dry to be swept up in the air and carried long distances by the wind.

COMPARISON OF THE ENGLISH AND PITTSBURGH RESULTS

The figures given in the above tables may be usefully compared with those collected in Table V and given in the course of an article by Mr. J. J. O'Connor upon Pittsburgh's soot and dust fall, which appeared in this journal in April, 1914 (Vol. XII, page 247). The principle of the method used for collecting the soot and dust was similar, but the Pittsburgh gage was much smaller in size than that used in England.

TABLE V—SOOT AND DUST FALL IN TONS PER SQUARE MILE PER YEAR IN PITTSBURGH, U. S. A. (BREMNER), APRIL, 1912, TO MARCH, 1913

Station No.	Tar Tons	Composition of Soot			Total Tons
		Fixed Carbon Tons	Ash Tons	Fe ₂ O ₃ Tons	
1	13	131	306	145	595
2	16	713	809	412	1,950
3	10	202	189	269	670
4	19	417	844	380	1,660
5	21	357	704	548	1,630
6	4	322	343	309	978
7	8	300	309	195	812
8	7	286	419	210	922
9	5	211	344	188	748
10	3	274	336	108	721
11	8	391	378	218	995
12	7	200	333	153	693

Average of twelve districts.....1,031 tons

The worst of the English towns, namely, Oldham, with a winter soot and dust fall at the rate of 1064 tons per square mile per annum, has, therefore, an atmosphere as dirty as that of Pittsburgh, with an average fall of 1031 tons per square mile per annum; whereas Sheffield, the center of the English steel-making industry, even in its dirtiest district of Attercliffe,



FIG. 3—THE STANDARD SOOT AND DUST GAGE AT LIVERPOOL, 1914

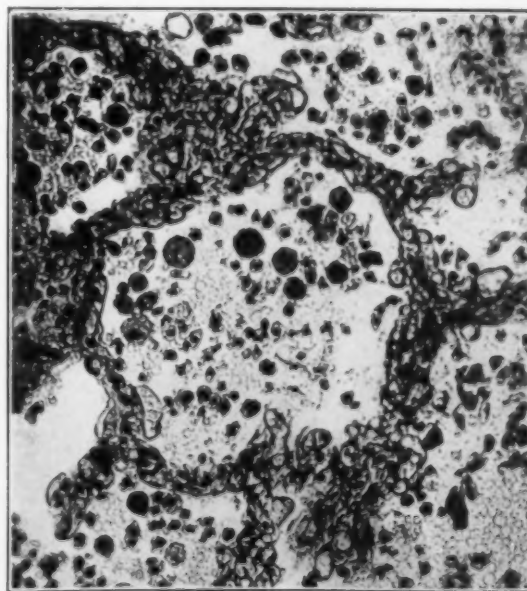


FIG. 4—A SECTION OF THE HUMAN LUNG, SHOWING SOOT DEPOSITS

shows a fall of only 642 tons in the twelve months, and is therefore far cleaner as regards its atmosphere than Pittsburgh. Possibly had the observations been carried on over a wider area at Sheffield, especially on the eastern side of the city, the results would have approximated more to those of Pittsburgh, for the prevailing winds at Sheffield are from the west and southwest.

In view of these results and facts, it is interesting to note that at the International Conference for the Prevention of Smoke, held in Pittsburgh in September, 1913, a committee was appointed to co-operate with the London committee in order to arrange for the introduction of the standard method of making these soot and dust observations in America. Mr. E. P. Roberts, the chief smoke inspector of Cleveland, was made chairman of this committee, and it may be hoped that shortly figures similar to those given in Tables I, II, III and IV will be available for some of the leading towns and cities of America.

THE SPECIAL INVESTIGATIONS AT MANCHESTER

The sanitary committee of the Manchester City Council in December, 1912, appointed an air pollution advisory board for the purpose of investigating and reporting upon the conditions of air pollution within the city area, and the first report of this advisory board to the sanitary committee, which has been recently published, forms a most valuable contribution to the literature of air pollution in towns. The board consists of the members of the sanitary committee, strengthened by other members of the City Council, and by a number of outside members of engineering and scientific societies especially interested in the smoke problem. It has no administrative powers, but is concerned solely with research and educational work.

For the purpose of more fully carrying out its objects, four sub-committees have been appointed, dealing with the *chemical, statistical, legal and engineering* branches of the problem. The chemical sub-committee,

of which Prof. H. B. Dixon of Manchester University is chairman, has made observations upon the loss of light due to the suspended solid impurities in the air of the city by three methods. A recording actinometer devised by Prof. Haldane Gee and Mr. W. C. Jenkins of the Godlee Observatory was used for some of the observations. The results obtained with this instrument at three different observation stations during July, August and September (1914) showed that the average intensity of the sunlight at Crewe was nearly 20 per cent greater than in the Whitworth-street Garden in the city of Manchester, and that on the roof of the School of Technology (100 ft. high) it was 12.6 per cent greater than at the ground level. In order to obtain records from some place well outside the local area, it has been arranged to install one of these recording actinometers at Abergele, in North Wales.

The instrument (see Figs. 5 and 6) consists of a fixed metal cylinder, 6 in. in diameter and $3\frac{1}{2}$ in. long. This cylinder is open at the bottom, but is closed at the top with a lid, having on its circumference a scale of hours and around its edge a scale of one-quarter hours. By the use of a clamping device photographic paper can be secured evenly on the surface of the drum. The lid is fixed to a curved metal upright supported on the wooden base of the instrument. The top of the upright is graduated from 50 to 55 deg., corresponding to local values of latitude. This enables the axis of the cylinder to be fixed at the required latitude by moving the curved arm until an index mark is at the right angle.

Concentric with the fixed cylinder is a movable one of a little larger size. On the bottom is a clock, with its driving axis passing through a hole in the metal bottom of the cylinder. This axis passes into a hole in a rod, and when the axis is held by turning a clamp screw, the outer cylinder, with its clock, revolves around the inner cylinder once in twenty-four hours. The clock runs for seven days, and after adjustment keeps good time. It may be noted that in the actinometer the axis is held and the clock rotates. This arrangement is the reverse of an ordinary clock.

To keep the cylinders concentric, a central rod is fixed to the center of the upper cylinder, and pivots in a central hole in the top of the clock case. On the rotating drum there are two fixed metal jaws provided with a slit between them. This slit is wider at the middle and tapers each way.

When in use the instrument must be placed with its axis in the geographical meridian, and the slit is brought opposite to the mark indicating solar time. The motion of the slit will then follow the sun, and the



FIG. 5—NEW FORM OF ACTINOMETER

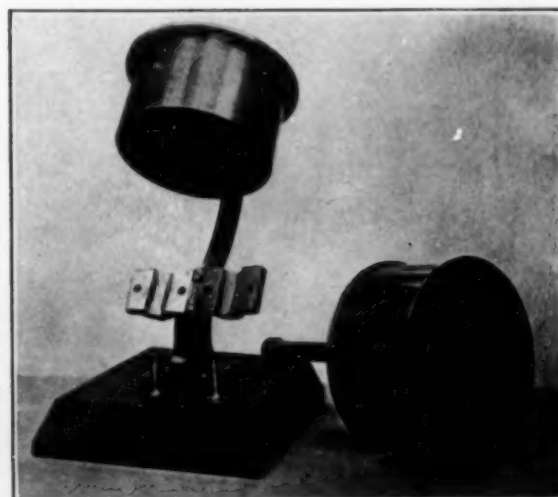


FIG. 6—NEW FORM OF ACTINOMETER—WORKING PARTS

intensity of the light will be indicated by the degree of blackening of the paper.

The type of paper best for the purpose has been the object of many experiments and inquiries. So far as the experimental work has been completed, it has been found that a gas-light paper that has been treated with a 5 per cent solution of resorcin, containing $\frac{1}{2}$ per cent of glycerine, is the most suitable paper for general use. The paper is sensitive to ultra-violet light, and to a certain extent toward the red end of the spectrum. The standard paper is prepared by the Ilford company.

It is proposed that all the exposed papers be sent to the School of Technology for examination and scaling. Much information can be obtained by the simple inspection of the records, but in order to obtain numerical values the surface brightness is measured by the aid of a portable photometer called a lumeter. The surface brightness is found to be, within certain limits, inversely proportional to the intensity of the received light. Where there is much variation in the daily record, the average value can be obtained by rotating the paper by means of an electric motor, and then reading off the resultant tint with the lumeter.

The ideal position for the actinometer is close to the ground, and such that the light is not obstructed from sunrise to sunset. It is difficult to obtain such a situation, especially in the city and suburbs, and although desirable it is not absolutely necessary, for useful observations can be taken even when freedom from obstruction is only for a part of the day. It is essentially important to place the instrument in the charge of persons who are accustomed to the regular use of instruments. The actinometer gives the intensity of the light directly received from the sun.

THE CONNECTION BETWEEN SUNLIGHT, PURE AIR AND HEALTH

In concluding this article a quotation may be given from the words of a famous scientist as to the intimate relation that exists between sunlight and health, and as to the effects of the soot and dust suspended in the atmosphere in screening off the active rays of sunlight from crowded city streets and tenements. Sir Oliver Lodge, the principal of Birmingham University, has stated:

"Under present conditions the greater part of humanity in England lives under a thin pall of obscure material, through which a certain amount of light and heat can pass, but which effectually screens the health-giving and disease-destroying actinic rays of the sun. Accordingly, frequent excursions in the country are needed for the preservation of even a moderate or residual amount of robust health, while the multitude condemned to live under unwholesome conditions suffer both in themselves and their children to a grievous extent."

This screening effect of a dust-polluted air is far greater than is imagined, for direct experiments in Manchester have proved that on a sunny day *no less than 12 per cent of the sunlight is cut off in the last 100 ft. of the atmosphere.*

There are three essential factors in the preservation of good health, namely, pure water, pure food, and pure air; and it is satisfactory to find that at last the importance of the third factor is being recognized. The soot and dust suspended in the atmosphere are disadvantageous and harmful to the living organism in several ways. In the first place by diminishing the amount of sunlight which falls upon the earth they directly lower the vitality of the human organism and diminish its power of resisting disease. Cohen has shown that in Leeds the smoky atmosphere cuts off from

25 per cent to 40 per cent of the sunlight, and the Pittsburgh and Manchester investigations have confirmed these results. The soot and dust suspended in the atmosphere also enter and choke up the pores and cells of the lung tissue to such an extent, that the rapid assimilation of oxygen by the blood, and discharge of CO₂ and other waste products, is checked. Doctors can always tell, by a post-mortem examination, from the color of the lung tissue whether the man has lived chiefly in the town or the country during his lifetime, and the shortened life of town-dwellers is partly due to this cause.

Finally, direct sunlight and pure air are now recognized as natural germicides, and the soot and dust suspended in the atmosphere therefore aid the propagation of all infectious diseases by promoting the conditions which are favorable to bacterial life.

The writer's thanks are due to Mr. J. J. O'Connor and to the directors of the Mellon Institute, of the University of Pittsburgh, to Professor Beattie and to Dr. Hope of Liverpool University, and finally to Professor Gee and Mr. W. C. Jenkins of Manchester, for information and for the loan of the photographs used in the preparation of this article.

Liverpool, England.

Recent Chemical and Metallurgical Patents

Iron and Steel

Low-Phosphorus Steel from High-Phosphorus Iron.—According to a process of ALVA C. DINKEY low-phosphorus steel is cheaply produced from iron containing phosphorus above the permissible or specified limit, as follows: A quantity of limestone and ore or other oxide of iron is charged into a furnace, the limestone amounting to about 5 per cent and the ore or oxide to about 15 or 20 per cent by weight of the metal to be treated. The charge is heated until it is at a red heat or is pasty and even fused. The charge of pig iron in a molten condition is then poured into the furnace as rapidly and as nearly at one time as possible. This causes an active reaction and a rapid production of basic slag, and the materials being at a comparatively low temperature, the iron oxide oxidizes, the phosphorus, silicon and manganese in the pig iron with extreme rapidity and at the same time oxidizes a slight portion of the carbon. At the end of about one hour, the phosphorus will be substantially eliminated, that is, reduced to about 10 per cent of its original content. The furnace is then tapped and the partly refined metal removed therefrom to a mixer or storage vessel for subsequent treatment in acid Bessemer converters. The iron will be treated in the preliminary furnace in about 50 to 100-ton lots and as the storage vessel has a much greater capacity (500 or more tons), a large quantity of partly refined or semi-finished metal can be stored therein. (1,162,755, Dec. 7, 1915.)

Sulphuric Acid

Contact Process for Sulphuric Acid.—In the contact process of making sulphuric acid it has been the custom to preheat the sulphur dioxide and air to about 400 deg. C. before passing them through the converter which contains trays of the catalytic mixture, usually MgSO₄ with 0.2 per cent platinum. The platinum acts as the catalyser. In the process there are three distinct steps, (1) the drying of the gaseous mixture, (2) the heating of same, (3) the treatment with the catalyser. In order to perform all these operations in one step a process has been patented by CLARENCE J. BROCKBANK of Niagara Falls, Ontario, Canada (assigned to the Carborundum Company). The gases are passed

through an acid-proof pipe in which is placed a porous diaphragm made of fine carborundum crystals (such as described in patent 992,698 of Frank J. Tone, May 16, 1911). This carborundum diaphragm is previously impregnated with platinum by immersing it in a solution of platinum chloride and heating whereby the chlorine is driven off and the platinum remains. This diaphragm is heated by joining it to electric terminals, as shown in Fig. 1. This process provides a means of controlling

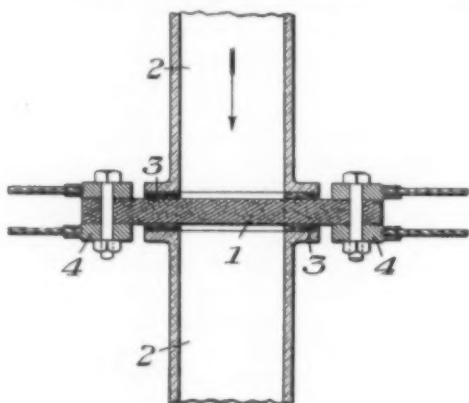


FIG. 1—CATALYTIC DIAPHRAGM

the temperature accurately (between the limits of 400 and 800 deg. C.) and the gases are instantly converted and a better yield is claimed to be attained. The carborundum plate is not attacked by fuming sulphuric acid and in case it is fouled by arsenic may be restored by immersing in aqua regia and heating. (1,157,293, Oct. 19, 1915.)

Gold and Silver

Hydrolysis of Alkaline Cyanides.—In addition to the action of cyanicides in destroying the efficacy of alkaline cyanides as solvents for gold and silver, "the principal loss is due to the formation of hydrocyanic acid by hydrolysis of the simple cyanide solution," according to letters patent granted to Mr. HUGH M. LESLIE, of Glasgow, Scotland. The patentee states that he has arrived at this conclusion as the result of extensive experiments to determine the loss of cyanide in the treatment of ores. The hydrocyanic acid evolved as the result of this hydrolysis is constantly passed into the atmosphere and lost. It is claimed that the presence of a large excess of caustic alkali in the ore pulp will not prevent this hydrolytic action. The inventor proposes, therefore, to recover this hydrocyanic acid and make it available for further dissolution of metal by covering the tanks used in the cyanidation of ores and conducting the evolved gas to absorption tanks where the hydrocyanic acid may be fixed in alkali. When thus recovered the cyanide is useful for further work on ores. A modification of his proposal is to arrange covered agitators and dewaterers in such a way that the pulp is gradually raised from one machine to the next by means of air-lifts, the hydrocyanic acid gas collected being introduced to the agitators with the air at each lift and thus caused to act on the pulp. (1,158,513-4, Nov. 2, 1915.)

Filter.—A filter of the drum type, for separating solids and liquid contained in an ore pulp, is shown in section in Fig. 2, being the patented invention of WILLIAM P. LASS of Treadwell, Alaska. The filter leaves 79 are stationary, resting on rollers 80 and supported between guides 83. Spray pipes 87 are provided for the purpose of spraying the leaves and discharging therefrom the cake formed in the filtering operation. Pulp to be filtered enters the bottom of the drum at 33.

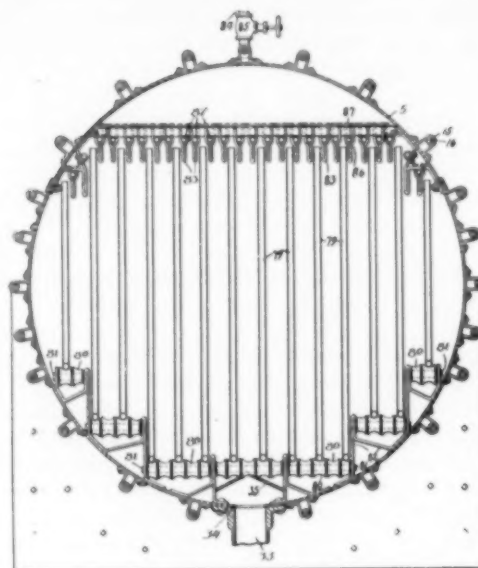


FIG. 2—FILTER

Compressed air is supplied to the drum by the pipe and valve 84, 85. When the pulp has filled the drum to a point above the filter frames, a valve is opened to permit the filtrate to run from the press through a pipe not shown. After a cake has been formed of the desired thickness, compressed air is admitted through 85, forcing the remaining pulp back out of the press through an exit pipe. Wash solutions may be introduced into and removed from the drum in the same manner, and after the cake has been washed it is blown from the filter leaves by reverse pressure of air or steam, and the discharge is facilitated by sprays of water from the pipes 87. The tailing pulp can be removed from the drum by screw conveyor or sluiced by the water sprayed from the pipes. (1,144,854, June 29, 1915.)

Copper

Flotation of Sulphidized Minerals.—A method of treating low-grade oxidized copper ores is disclosed in the specifications of a patent granted to HENRY B. HOVLAND of Duluth, Minn. He proposes to dissolve the copper in sulphuric acid, and then sulphidize the metal by adding to the pulp a mixture of calcium sulphide and ferric sulphate, the latter to facilitate the conveyance of the sulphur to the metal to be sulphidized. The copper thus treated can then be recovered as a concentrate by flotation. Calcium sulphide is mentioned as the sulphidizing agent as it is a cheap material, easily prepared from lime and sulphur, or by reducing gypsum. (1,159,942, Nov. 9, 1915.)

Precipitating Copper from Solution by SO_2 .—A suggestion for recovering metallic copper from its solution as a sulphate is contained in a patent granted to GEORGE D. VAN ARSDALE of East Orange, N. J. After the copper is dissolved from its ore the solution is separated from the gangue in any desired manner, and is then saturated with sulphur dioxide to effect a precipitation of metallic copper under certain conditions of heat and pressure. Sulphuric acid is regenerated in the precipitating process and can be used for the treatment of additional ore. In the treatment of ores containing practically no soluble constituent except copper, an excess of free sulphuric acid is generated. It is advantageous to neutralize this excess of acid, or part of it, and thereby control the amount of copper precipitated. Since two molecules of H_2SO_4 are formed for every molecule of copper precipitated, and if it is de-

sired to neutralize one of these by the use of CaO, it will be necessary to add CaO in the ratio of the molecular weights of copper and lime, or 63:56. The proportionate amount of lime used will vary with the conditions which it is desired to maintain in the solution, or in other words, in accordance with the yield of copper required or the amount of free acid which is to be left in an unneutralized condition. (1,147,466, July 20, 1915.)

Synopsis of Recent Chemical and Metallurgical Literature

Chemical Engineering

Development of an Acid-Resisting Alloy.—An interesting paper on a new acid-resisting alloy was presented by Prof. S. W. PARR of the University of Illinois at the meeting of the American Institute of Metals at Atlantic City, Sept. 28, 1915. The increasing cost of platinum prompted the author to attempt to find an alloy that could replace it in some uses. The problem contained many difficulties as so many properties were required viz.: resistance to acids, density, strength, workability and resistance to corrosion. The "cut and try" method had to be resorted to for the most part, although the guiding theoretical consideration was to arrange the constituents so that as far as known the electro-positive and electro-negative properties would neutralize each other and produce a potential of zero. The lack of practical working data on this question and the ever presence of impurities and their great effect made exact applications of the theory out of the question.

An alloy was, however, found with a degree of resistivity which had hardly been thought possible. The unit of reference for measuring the amount of corrosion was adopted as follows: A standard disk of the alloy was prepared having 10 sq. cm. of surface. This was submerged for a given length of time, usually twenty-four hours in nitric acid of approximately 25 per cent HNO_3 . The loss in weight was calculated to the amount which would be represented for an area of 100 sq. cm. per hour.

In test No. 23 a small casting of simple form was secured from which the test piece showed a loss in weight referred to this unit of surface and time of 0.03 mg. In test No. 40 a casting of more difficult form was secured weighing about 10 lb., the test piece from which gave an equally high degree of resistivity. In the last seven castings of similar size, Nos. 133 to 136 inclusive, six out of the seven standard disks did not show a weighable loss after contact with the nitric acid for twenty-four hours.

The casting and working properties of the alloy had to be promoted in all of the modifications. At first thought this would seem to multiply the difficulties. On the contrary it proved to be more of an advantage than otherwise. That is to say, each additional element would tend to lower the melting point of the alloy and reduce the tendency to form an open texture or coarsely crystalline structure. If the resulting composition seems to be unnecessarily complex, the above statement may be a partial reason for that result.

An analysis (by S. A. Braley and F. E. Rowland) of a representative sample is as follows:

Cu	6.42
Mn	0.98
Si	1.04
W	2.13
Ni	60.65
Al	1.09
Fe	0.76
Cr	21.07
Mo	4.67
	98.81

Carbon and boron not determined.

The casting of the alloy proved to be quite as serious a problem as the development of the composition. The melting point is approximately 1300 deg. C. The furnace must be capable of readily attaining the temperature of molten nickel, say 1600 deg. When thoroughly liquid the alloy pours readily and fills the mold perfectly but the freezing point is so quickly reached that feeding of the casting from risers, to make up for shrinkage, is practically impossible. Moreover the shrinkage is so excessive that cracks and hollow spots are very difficult to avoid. This feature can be perhaps better appreciated when it is noted that the most important instrument in mind for use of the alloy was a calorimeter bomb, which consists essentially of a chamber of approximately 35 cu. in., which must retain absolutely without leakage, a gas at an average pressure of 25 to 30 atmospheres.

Here again the very complexity of the composition has probably been the chief factor in securing a metal which could by any means be cast in the dense, homogeneous form required. It works about the same as tool steel. The interior surfaces of the bomb and cover show no trace of corrosion after use in over 1500 determinations using the apparatus in determining the heating value of coals. In each determination there is generated a considerable quantity of nitric and sulphuric acids which condenses on the interior surfaces of the bomb. Under the prevailing conditions of heat and high oxygen pressure the best possible conditions exist for the promotion of corrosive action.

Attempts to draw the alloy into wire and roll it into sheets have been only partially successful, but sufficient to show the likelihood of success when the conditions for proper annealing are better understood. The tensile strength of the cast metal is approximately 50,000 lb. per square inch. The name suggested for the alloy is "Illium."

Gold and Silver

Zinc-Dust Precipitation Tests.—An A. I. M. E. paper presented at San Francisco gives a discussion of observations made by NATHANIEL HERZ on laboratory tests of a large variety of zinc-dust samples. The author used the efficiency test of W. J. Sharwood, as follows:

"A solution of potassium silver cyanide is prepared by dissolving 10 grams silver cyanide (AgCN) and 5 grams of '90 per cent' potassium cyanide in a little water and diluting up to 1000 cc. It is then adjusted by addition of a little more KCN or AgCN until the solution indicates from 0.12 per cent to 0.15 per cent free KCN by titration with standard silver nitrate. The titration is best made by using a 10-cc. or 20-cc. sample, adding 1 cc. of 2 per cent potassium iodide, and a slight excess of ammonia; the end point is then sharper. Or 15 grams of pure crystallized KAg(CN)_2 may be dissolved in a liter of water and 1.5 grams KCN added.

"Weigh out 0.5 gram zinc dust into a 300-cc. beaker. Add a few cubic centimeters of water and stir until zinc is well mixed, then pour in 250 cc. of the prepared solution, stirring vigorously. See that all lumps are broken up, and continue stirring for fully five minutes. Stir occasionally (at least every 10 minutes) until the end of two hours from the addition of the solution. Then filter upon an 11-cm. filter, wash precipitate thoroughly, sprinkle with test lead, wrap it carefully in the paper, place in a scorifier with about 20 grams test lead, burn paper cautiously in muffle, scorify five minutes, cupel at low temperature and weigh silver. Milligrams silver obtained from 0.5 gram zinc $\times 0.0606$ = percentage precipitating efficiency."

Substitution of sodium for potassium cyanide gave no variation in results. Precipitation of gold solution gave only about one-half to one-third the efficiency observed with silver solutions. Mixed gold and silver solutions gave efficiency intermediate that of silver and gold alone, the beads containing four atoms silver to one gold. Slight variations in free cyanide present do not affect results materially, but the quantity cannot be reduced to 0.01 per cent without giving very different results. In some cases exposure of the zinc dust to moist air for several hours seemed to increase efficiency of precipitation. Other tests indicated that the oxidation of zinc dust by exposure to dry air is practically negligible. In moist air, on the other hand, oxidation may amount

to as much as 2 or 3 per cent per day, falling off as oxidation proceeds. The efficiency of precipitation is not reduced as much as commonly supposed.

Lead increases the activity of zinc in cyanide solutions, and cadmium would probably also help, though not as much as zinc. Analyses of samples showed the lead content to vary from 0.15 per cent to 5.2 per cent, and cadmium from *nil* to 3.9 per cent. Zinc oxide varied from 6.3 per cent to 17.85 per cent. Some carbonaceous matter occurs in some samples, but is inert. Carbon dioxide also occurs, but in such small quantities as to be of no material effect in precipitating calcium carbonate and thus preventing contact of zinc with cyanide solution. Some dusts contain an oily material of some kind, and such dusts are improved by exposure to air.

The author gives the following requisites in zinc dust for satisfactory precipitation: Most of it should pass a 200-mesh screen, and the fine portion should be much finer than the screen opening. Oxide should be low, although this does not necessarily indicate a good dust. Lead should be present at least over 1 per cent, and 4 per cent may do no harm. The value of the dust for precipitating purposes can be determined rapidly by testing with standard silver cyanide. If the efficiency is well over 40 per cent, the dust is satisfactory; if under 30 per cent, the dust may give poor results.

Lead

The Newnam Mechanical Lead Hearth.—A successful effort to mechanize the ore hearth for smelting galena is recorded by Mr. WILLIAM E. NEWNAM of Collinsville, Ill., in a paper prepared for the next meeting of the American Institute of Mining Engineers. The field of the ore hearth in lead smelting is confined to the treatment of non-argentiferous galena containing over 68 per cent lead. The advantages of this method of smelting are the lower cost of pig lead, the immediate reduction of 55 to 65 per cent of the lead content of the concentrate, with simultaneous roasting, thus producing a small tonnage of gray slag which is an ideal feed for the blast furnace. The disadvantages of the method are the limited size of units, 4 ft. to 5 ft., requiring two men per eight-hour shift; small product per man; hot and laborious work with danger of lead poisoning from dust and fume; large flue and bag-house system required to catch dust and fume which must be re-treated.

After a careful study of the hand-hearth operation, it was decided that three things were necessary to perfect it, namely: A cool and sanitary hood; a mechanical rabbler which would effectually replace the continuous and laborious use of the hand rabble, and a lead-well attachment that would mold clean lead direct from the hearth basin with little attention on the part of the furnacemen.

Experiments were carried out on the ordinary 4-ft. hand hearth. The hood problem was taken up first; and soon a double hood was devised which gave the furnace room a clear and fume-free atmosphere, at the same time reducing the direct and radiated heat to the workmen 50 per cent. A complete cessation of sickness and an increased output were at once noted.

After a few trials a simple and effective lead well and molding device was installed.

A traveling rabbler was next put on the 4-ft. furnace, and, after numerous changes, a successful type was worked out.

This rabbling machine is hung from a carriage which travels on an overhead track, and it rabbles in one direction only, for a reason given later. The machine being in such a position that the rabble arm is at the extreme end of the furnace, a releasing lever is pulled, which starts the machine, causing the rabble arm to

describe a motion which is similar to that of the hand rabble, but more effective, since there is more power behind it. As the rabble arm is withdrawn from the fire, an eccentric connected with a ratchet wheel moves the carriage forward about 4 in. for the next stroke of the rabble arm. This motion is repeated until the other end of the furnace is reached, when the machine automatically stops and withdraws the rabble arm from the fire.

Two men, a charger and a helper, operate the furnace. The helper follows close behind the rabble arm and with a long-handled shovel pushes back the loose charge, picking out the gray slag as he goes along. Close behind the helper comes the charger, who spreads a thin layer of ore on the charge as fast as it is shoveled back by the helper, adding coke breeze as needed.

Thus the fire is exposed for an instant only, and by the time the trip down the furnace is completed the end first charged is ready for the rabbling machine. It is for this reason that the rabbling is performed in one direction only. The first trip being complete and the gray slag removed from the apron, the throwing-in of a clutch causes the carriage to return without rabbling to its original position, where it automatically stops in readiness for a second rabbling trip.

Thus on each trip the fire is rabbled twenty-four times in forty-eight seconds, the return motion require twelve seconds. One horsepower is required under full load, and is supplied by a 1-hp., alternating-current 220-volt motor. The rabbling machine is simple, strong, and durable, and only requires a few minutes' attention daily.

From the data compiled it was determined that the hearth could be increased to 8 ft. in length, that it would then produce two and one-half times as much pig lead as the hand hearth; and that two men could operate it with less fatigue than that sustained by two men on the ordinary hand hearth. An 8-ft. hearth was at once constructed and from the first day of its operation it has not only realized our expectations but considerably exceeded them.

The following table is a comparison of the two types of hearth, operating side by side on the same ore, showing the average results per eight-hour shift over a period of four weeks, the labor being the same on each type. Ore charged, galena concentrates, containing 72.5 per cent lead, and 15.1 sulphur.

	Newnam Hearth, Pounds	Hand Hearth, Pounds
Dry ore charged	13,179	5,091
Lead contents	9,554	3,691
Pig lead made	8,443	2,030
Gray slag made	3,318	1,329
Per cent of coke breeze used	3.6	8.8
Rabble trips per hour	37.2	....
PERCENTAGE OF TOTAL LEAD IN PRODUCTS		
Pig lead	67.44	55.00
Gray slag	15.18	16.20
Dust and fume	17.38	28.80
	100.00	100.00

	Pb	FeO	CaO	S	Insoluble
Newnam hearth	43.7	12.8	9.9	1.9	12.6
Hand hearth	45.0	12.2	9.0	2.6	12.2

Taking the above average runs as a basis, the sulphur elimination is calculated as follows:

NEWNAM HEARTH				
	Pounds	Sulphur, Per Cent	Sulphur, Pounds	Sulphur, Pounds
Dry ore charged	13,179	15.1	..	1,990
Gray slag	3,318	1.9	63	..
Dust	776	11.1	86	..
Burnt fume	1,552	5.9	92	241
Pounds of sulphur eliminated .....	..	..	..	1,749
Per cent of sulphur eliminated .....	..	..	..	87.9
HAND HEARTH				
	Pounds	Sulphur, Per Cent	Sulphur, Pounds	Sulphur, Pounds
Dry ore charged	5,091	15.1	..	769
Gray slag	1,329	2.6	35	..
Dust	497	11.1	55	..
Burnt fume	994	5.9	59	159
Pounds of sulphur eliminated .....	..	..	..	620
Per cent of sulphur eliminated .....	..	..	..	80.6

Ozone for Ventilation

The following is a report of the test of a Westinghouse air ozonizer, together with the results of the experiments on air ozonization which have been carried out by Mr. SHEPPARD T. POWELL for Messrs. Wehr and Walden, engineers, of Baltimore, Md., during the past year. The investigation was carried on under conditions ordinarily encountered in a chemical laboratory, and for this reason the results obtained may be somewhat at variance with the results of other investigators who worked under local conditions more favorable for such work. Notwithstanding this fact, the results of the tests reported are instructive in determining the efficiency of air ozonization.

The investigation was conducted to determine:

1. The efficiency of the generator in respect to the production of ozone, especially in reference to its operation under varying weather conditions and air velocities through the tubes.
2. The effect of the gas upon odors in the air and to determine the failure of ozone to remove or mask odors caused by certain compounds.
3. The efficiency of ozonized air in the destruction of bacteria and similar micro-organisms present in the atmosphere.

It was not within the scope of the laboratory to touch upon all phases of air ozonization, so that the investigation was narrowed down to these three points, as these are the all important aspects of the purification of air by means of ozone.

LABORATORY APPARATUS AND METHODS EMPLOYED

The ozone generator used in this work was the standard Westinghouse air ozonator. This generator consists of a cylindrical metal case containing four glass tubes, 2 in. in diameter and 9 in. long, on which there is a metallic coating and within the tubes is wire gauze. In the lower portion of the case is placed the step-up transformer, the high-tension leads from which are connected, one to the wire gauze on the interior of the glass tubes and the other to the metallic coating on the outside of the glass tubes, the glass tubes thus serving as the dielectrics between the metallic electrodes. The production of ozone is controlled by means of a switch so that one or more tubes can be operated at the same time.

For this work the lower half of the generator was inclosed within a practically airtight wooden box, and over the top of the generator was a metallic hood serving the purpose of a container or reservoir for the collection of samples of the gas.

A $\frac{1}{8}$ -hp. blower was used for varying the air velocity through the generator tubes, the outlet of the blower being connected directly to the wooden case of the ozonator by means of a 4-in. metal pipe. When the blower was in operation the air entering the apparatus was filtered by means of an absorbent cotton felt mat. A sketch of the apparatus is shown in Fig. 1.

The method of analysis used in determining the concentration of the gas was a modification of the Treadwell Hall method.¹ The method consists in aspirating a known volume of the ozonized air through a 2N potassium iodide solution contained in a specially designed absorption bottle (the volume of the sample depending upon the concentration of the ozone). To the ozonized KI solution are then added 5 cu. cm. of 1 to 3 sulphuric acid and titrated immediately with $\frac{N}{24}$ sodium thiosul-

phate, finishing the titration by means of starch. The concentration of the gas is reported in milligrams of ozone per liter of ozonized air, which is equivalent to grams of O_3 per cubic meter by the following formula:

$$O = \frac{AN}{R}$$

in which O is the number of milligrams of ozone per liter of ozonized air, A the number of cubic centimeters of thiosulphate solution required, N the strength² of the solution, and R the number of liters of gas that passed through the KI solution.

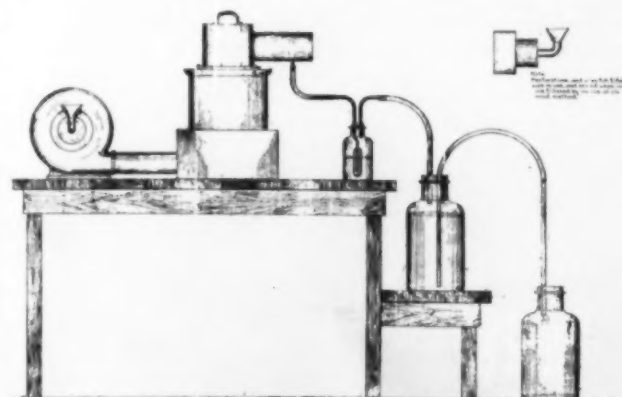
The culture medium used in the bacteriological work that was done was nutrient gelatine prepared according to the methods recommended by the A. P. H. A. for water and sewage analyses. The culture plates were incubated for forty-eight hours at a temperature of 18 deg. to 20 deg. C. There are no methods known to-day which will give an accurate count of the total number of organisms present in the air, but in all probability the method employed will give quite as accurate and reliable results as many of the more elaborate methods that have been used by investigators recently in similar experiments.

RESULTS OF EXPERIMENTS TO DETERMINE THE YIELD OF OZONE FROM THE GENERATOR

The heat generated by the transformer as well as that from the brush discharge warms the air within the ozonator so that the air entering the bottom of the drum rises, causing the ozone to leave the generator at the top of the apparatus. However, as ozone has a specific gravity somewhat higher than that of air the gas must be heated to such a temperature as to overcome the tendency of the gas to leave from the bottom of the apparatus. A number of tests were made to determine if there was any uniform rate of heating of the tubes, or uniform time element in the reversal of flow of the gas through the machine.

As it was not possible to obtain any accurate temperature reading within the tubes of the ozonizer, these tests were made by means of moistened starch iodide paper. Strips of this sensitized paper were placed opposite the openings at the bottom and top of the generator and the presence of the gas noted by the blue color formed.

In every instance the ozone passed from the bottom of the generator when the apparatus was first put in service irrespective of the setting of the switch. After running the apparatus for a time, varying from one minute to twenty minutes, the flow of the gas was reversed and flowed from the top as long as the ozonator was in operation. As would be expected, there is apparently a critical temperature at which this change



GENERAL ARRANGEMENT OF THE OZONATOR, BLOWER AND SAMPLING OUTFIT USED IN THE OZONIZING EXPERIMENTS

¹Treadwell Hall's Analytical Chemistry, Vol. II, page 676.

² $\frac{N}{24}$ thiosulphate solution 1000 c.c. = 1.0 gram of O_3

24

1 c.c. = 1.0 milligram of O_3

takes place, but there is no uniform rate of heating the tubes under uniform atmospheric conditions and current consumption.

A great number of determinations were made of the concentration of the gas generated with each setting of the switch. From these tests it was clearly demonstrated that the yield of ozone is in direct proportion to the setting of the switch, as has been stated by the manufacturers.

The average concentration in milligrams of ozone per liter of ozonized air for each setting was as follows:

Setting	1	2	3	4
Concentration	0.0150	0.0900	0.1500	0.1800

These concentrations are very constant, the greatest variation being about 5.0 per cent, covering all tests under various atmospheric conditions.

Although it is a well-known fact that humidity in the atmosphere has considerable effect upon the yield of ozone from large installations, still tests of this apparatus in the laboratory gave no evidence of this upon the concentrations produced with very great change in the humidity of the air, as can be seen from Table I:

TABLE I.—VARYING HUMIDITY				
Setting	1	2	3	4
Humidity..... 58 }	0.0150	0.0910	0.1500	0.1750
Temperature..... 68 }				
Humidity..... 76 }	0.0151	0.0900	0.1500	0.1800
Temperature..... 72 }				
Humidity..... 84 }	0.0150	0.0910	0.1450	0.1900
Temperature..... 76 }				

Tests made by varying the velocities of air passing through the tubes showed conclusively that the concentration of ozone was affected by the volume of air passing through the tubes. In Table II are given concentrations effected by various air velocities.

TABLE II.—EFFECT OF AIR VELOCITIES UPON THE AMOUNT OF GAS PRODUCED				
Setting of Switch	Temp. of Air	Humidity of Air	Concentration of O ₃ Grams per cu. M.	Cu. Ft. of Air Passing Through Tubes per Minute
4	70° F.	68	0.0075	7.46
4	70° F.	70	0.0019	18.63
4	70° F.	70	0.0006	37.31
4	72° F.	70	0.0001	74.62

EFFECT OF OZONE UPON ODORS

In undertaking laboratory experiments to determine the effect of ozone upon various odorous compounds, Mr. Powell approached the subject with some doubt as to the ultimate success of the undertaking, considering the complexity of the subject.

Technical papers within the past year have been filled with lengthy reports as to the value or futility of ozone as a deodorizing agent, but as yet the results seem futile; but at least the fact has been demonstrated that practical tests are of far greater value than laboratory tests, no matter how complete or scientifically they may be conducted. For this reason the experiments that were undertaken were merely to note if ozone in suffi-

cient concentration could remove certain of the common odors to be met with in daily work.

Temperature, humidity or other conditions are seldom, if ever, identical in different places; nor is it reasonable to expect to find the same odors present, either alone or in combination, in the same degree of intensity or in similar mixtures, so that broad conclusions have not been drawn from these tests, but they are merely reported to show the possible deodorizing effect of ozone upon certain organic compounds.

The substances used in these tests were mercaptan, skatol, oil of cloves, oil of violets, bullion cultures inoculated with sewage bacteria, cigar smoke, decayed fruit, sour milk, cheese, ammonia and hydrogen sulphide.

The details of these various tests are given in Table III.

In reviewing the foregoing work it is evident that many of the compounds causing their characteristic odors are easily oxidized by ozone, and that the products of oxidation are inodorous. As a result ozone can be depended upon to remove them from the atmosphere. Others are not so readily oxidized, but in the presence of ozone are not detected, but after the ozone has been completely used up are again evident, due to incomplete oxidation. Or as a third possibility the products of oxidation possess characteristic odors which persist in the atmosphere after ozonization.

EFFECT OF OZONE UPON THE BACTERIA OF THE AIR

In studying the sterilizing effect of ozone upon the bacteria of the air a number of determinations were made before and after ozonization. In the first series of tests a number of sterile petri dishes were exposed to the air of a room for given periods of time, varying from five hours to twenty-four, at different elevations, so as to obtain as near as possible a fair average of the number of organisms that were present in the air. Gelatine media were then put into the plates and the cultures incubated for forty-eight hours at 18 deg. to 20 deg. C. The average results of the tests are given in Table IV.

TABLE IV.—EFFECT OF OZONE UPON BACTERIA IN THE AIR. AVERAGE OF TEN TESTS

Bacterial colonies counted before ozonization	Time Plates Were Exposed—		
	5 Hours	15 Hours	24 Hours
Bacterial colonies counted after ozonization	30	41	83
Percentage reduction in bacteria....	3	4	5
	90	90.2	94.0

(Concentration of ozone during test 0.1500.)

The second series of tests that were made to check the figures given above consisted in passing a measured volume of air through an absorbent cotton filter and determining the number of organisms in a cubic foot of air of the room by washing a square inch of the filter material in sterile water, plating a portion of the water and counting the colonies developed upon the culture

TABLE III.—EFFECT OF OZONE UPON ODORS

Compound Causing the Odor	Concentration of Ozone	Intensity of Odor—				Control Test (After 24 Hours)
		Before Ozonization	After 3 Hours	After 5 Hours	After 24 Hours	
Skatol	0.1800	Strong	Fairly strong	Fairly strong	Very faint	Positive
Mercaptan	0.1800	Strong	Strong	Strong	None	Positive
Oil of cloves	0.1500	Strong	Strong	Odor changed	None	Positive
Bacterial culture	0.1800	Strong	Strong	Very faint	Very faint	Positive
Tobacco	0.1800	Strong	Fairly strong	Faint	None	Positive
Decayed onion	0.1750	Strong	Strong	Strong	Fairly strong	Positive
Ammonia	0.1800	Strong	Strong	Strong	Fairly strong	Positive
Hydrogen sulphide	0.0900	Strong	Faint	None	None	Positive
Cheese	0.1500	Fairly strong	None	.....	.....	Positive
Oil of violet	0.0900	Strong	None	None	None	Positive
Sour milk ^a	0.1500	Fairly strong	None	.....	.....	Positive

Note.—All control tests gave characteristic odors of substances used after standing twenty-four hours in a room in which there was no ozone.

^aAlthough in these tests it was noted that the odor of sour milk was eliminated by the use of ozone, it has been shown that when fresh milk is sterilized by the use of ozone the odor of the gas is retained by the milk, so this has not proven a practical method of sterilization.

plates. Such a procedure is open to error, but within reasonable limits of accuracy for comparative results.

The third method employed was similar to the second, with the exception that the filter medium used was sterile sand in place of a cotton felt. This method is the one in vogue generally in making ventilating investigations.

The results of both tests are reported in Tables V and VI.

TABLE V.—EFFECT OF OZONE UPON THE BACTERIA OF THE AIR
Bacteria per Cu. Ft. of
Air in Room

Concentration of Ozone Used in Tests	Before Ozonizing	After Ozonizing for 5 Hours	Per Cent Reduction After Ozonizing
0.0075 grams per Cb. M.	32	14	56.2
0.0019 grams per Cb. M.	28	24	14.2
0.0006 grams per Cb. M.	39	40	+2.5

TABLE VI.—EFFECT OF OZONE UPON THE BACTERIA OF THE AIR
(SAND FILTER METHOD)
Bacteria per Cu. Ft. of
Air in Room

Concentration of Ozone Used in Tests	Before Ozonizing	After Ozonizing for 5 Hours	Per Cent Reduction of the Bacteria
0.0065 grams per Cb. M.	41	12	70.7
0.0014 grams per Cb. M.	36	31	13.8
0.0007 grams per Cb. M.	46	42	8.6

Note.—In tests made in the office of the same company, 100 West Fayette Street, Baltimore, Md., it was found that the total number of bacteria was reduced after ozonization by 88 per cent, while the B. Coli content of the air was reduced 96 per cent.

CONCLUSION

In summing up the results of laboratory tests of this character due consideration must be given to the fact that the conclusions reached are based upon the results of tests conducted under conditions not usually present in other places. Such results are, therefore, only relative and are of value only when considered in this way.

Regarding the production of ozone by the machine, it is believed that within reasonable limits constant at the various settings of the switch that the yield of gas is but slightly, if at all, affected by temperature and humidity conditions, or at least to so slight an extent in a small generator of this type as to be negligible. The velocity of the air passing through the tubes, however, has a direct bearing upon the amount of the gas generated, the figures obtained showing that the slower the velocity of air passing through the tubes the greater the yield of ozone.

In reference to action of ozone upon the bacteria of the air, it has been demonstrated in these tests that comparatively high concentration acting for a long period of time has a great germicidal action upon organisms in the air, but the efficiency is lessened as the concentration is reduced. The tests made, however, clearly demonstrated that even low concentrations can be depended upon to eliminate to some extent the bacteria in the air of a room.

As to the effect of ozone upon various odors, it has been shown to the satisfaction of the author that the gas will rapidly remove odorous compounds from the atmosphere, provided the substances are oxidizable and the oxidation products are inodorous. All odors are probably not oxidizable, and under such conditions there may be a masking effect due to the more powerful odor of ozone, which has been noted in so many investigations. Also the complete removal of a substance causing a characteristic odor will require a given amount of gas to complete the oxidation reaction, and if the ozone is not sufficient to accomplish this then it cannot eliminate the odor.

Concerning the effect of ozone upon the health of persons, the subject cannot be dealt with here other than to state the effect upon the author. Very high concentrations have caused a dull headache and a feeling

of irritation in the throat, but under this condition the author has been subject to very high concentrations in a closed room for long periods of time. Lower concentrations, however, have not been objectionable in any way, and the author has worked for several weeks, five to seven hours a day, in an atmosphere where the odor of the gas was perceptible at all times with no detrimental effect.

In tests made at the large ozone plant there has been no complaint made by the operators as to the detrimental effect of ozone upon the health of these men, yet they have been working in an atmosphere of ozone highly concentrated eight to ten hours a day for many months; but in this case they have access at all times to outside air and do not stay continuously in the ozonizer house. The only comment that has been made by these men is to the effect that they are freer from colds since operating the ozone plant and are exposed to the gas than they were before the installation of this plant.

Oil Drying and Purifying Outfits

To obtain the best service as well as to economize in the use of oil for cooling and insulating transformers, high-tension switches, circuit-breakers, electrolytic lightning arresters, and similar apparatus, it is necessary to employ some method of cleaning and dehydrating the oil from time to time. If means for thus treating the oil are not available, it must be discarded at the time and replaced by new oil free from dirt and moisture.

Both the capacity and the voltage of transformers have been steadily increasing, making it necessary that the oil used be of extremely high quality as regards its purity and freedom from moisture.

It is well-known that the presence of moisture in transformer oil, even in the most minute quantities, very seriously affects the dielectric strength of the oil. Carefully conducted tests made by the Westinghouse Company have shown that 0.001 to 0.005 of 1 per cent (1 part in 100,000 to 20,000) will reduce the dielectric strength below the standard test value of 30,000 volts between $\frac{1}{2}$ -in. spheres spaced 0.15 in. apart, and 8 in. below the oil surface. Particles of dust, or other foreign matter in suspension also reduce the dielectric strength and in addition form undesirable deposits, necessitating that the oil be kept free from sediment as well as moisture.

After careful investigation of the problem of reclaiming all insulating oils whose deterioration has been caused by physical changes, or the presence of moisture, carbon or foreign substances, the Westinghouse company has developed a special type of filtering outfit for this service. In this outfit the oil to be purified is forced through several layers of specially prepared filter paper. The sediment is strained out by the first layer of paper

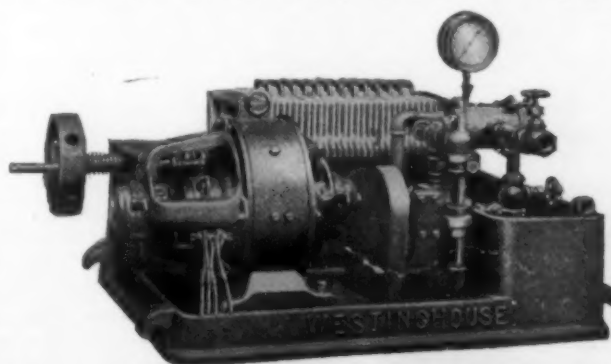


FIG. 1.—TYPE A-10 OIL DRYING AND PURIFYING OUTFIT

and the moisture is taken up by the capillary action of the paper.

While the principal class of service for which these outfits are developed is for the treatment of insulating oil, there are numerous applications for which they are well fitted. Insulating varnishes, compounds, etc., that have a sufficiently low viscosity may be cleaned and dehydrated. Machine oil of all kinds, petroleum, benzine, etc., may be effectively cleaned and dehydrated.

The complete outfit consists of filter press, motor, pump, oil strainer, pressure gage and piping. The sizes up to and including 10 gal. per minute are mounted on a neat iron base cast with a high rim that forms an enclosure and serves as a drip pan. The 20-gal. and 30-gal. per minute sizes are mounted on a structural iron base and have a sheet-metal drip pan. Electric drying ovens are supplied for drying the filter paper. The apparatus is manufactured by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Turbine Vacuum and Low Pressure Boiler Feed Pump

A combined turbine vacuum and boiler feeder pump, designed primarily for vacuum steam-heating service, has recently been placed on the market. This pump may be used equally as well on any service where both air and water, either hot or cold, have to be handled under a vacuum. The air pump and water pump are both on the same shaft and inclosed within the same casing. The air and water are separated before reaching the pump, each material being handled by itself. Other steam-heating vacuum pumps receive the water and air mixed, the separation being made under boiler pressure after leaving the pump.

The pump is shown in Fig. 1, and the complete outfit

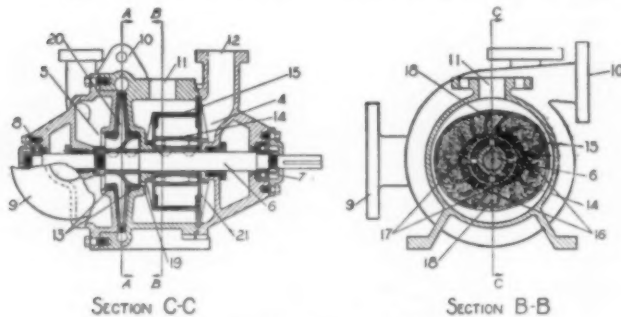


FIG. 1.—SECTIONS OF PUMPS

in Fig. 2. The pump is simple, consisting of a Nash hydro-turbine air pump and a Jennings centrifugal water pump combined in one casing. Fig. 1 shows the interior construction of the combined pump and a section of the air compressor. The air pump is at 4, the water pump at 5, both the air rotor and the water impeller being mounted on the same shaft 6, which is supported by annular ball bearings. The water inlet is at 9, the water outlet at 10. The air inlet is at 11, the air outlet at 12.

The air pump is positive in action and will give a maximum vacuum of 20 in. of mercury. A description of this pump was given in our issue of July, 1915. It consists of a rotor 14, turning freely in an elliptical casing 15. The rotor carries water around with it, the water following the casing due to centrifugal force. The water alternately receding from and surging back into the rotor, acts as a piston, drawing the air in and expelling it through ports 16 and 17, cut in the sides of the casing. A small amount of water is carried over with the air, and water is therefore constantly supplied to the pump through 19.

The water pump is a Jennings centrifugal pump, the liquid being rotated in an impeller. The interior of the pump requires no lubrication, a considerable saving in lubricant is effected, and what is more important, there is no danger of putting oil from the pump into the boiler.

In operation the heating returns, air and water, pass through strainer *B* into separating tank *C*. The water falls to the bottom of the tank *C* and passes into the centrifugal through the pipe *D*, driving the air out of the centrifugal through the pipe *L*. The pump fills with water and begins to pump, emptying tank *C*. The cen-

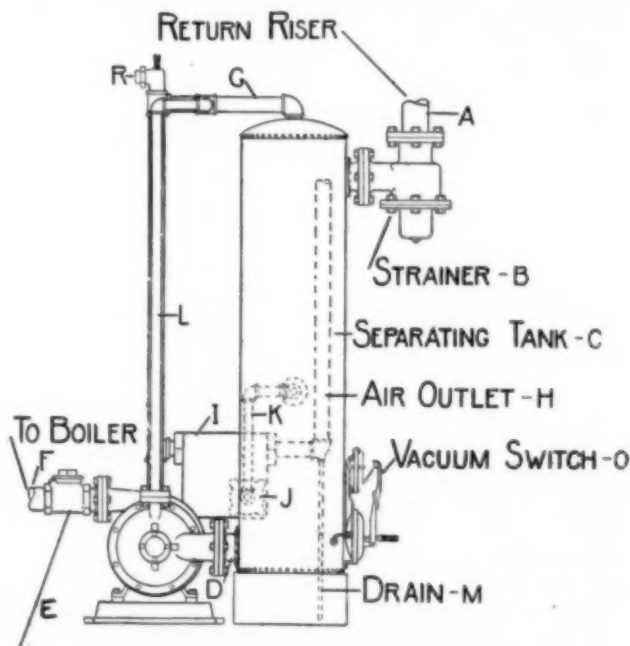


FIG. 2—PIPING CONNECTIONS

trifugal then stops as it cannot handle air, the check valve *E* preventing a back flow. The air is drawn out through *G* by the hydro-turbine.

Automatic control is furnished both for vacuum and water head. This is accomplished by means of switch shown at *O*. *I* is a separator for receiving the small quantity of makeup water from the centrifugal. The relief valve *R* is provided to prevent the vacuum from ever rising above the predetermined amount.

The pumps are furnished in five different sizes, ranging from 6 to 42 cu. ft. of air per min. and 11 to 90 gal. of water per min. at 10-in. vacuum and 10 lb. pressure. They are made by the Nash Engineering Co., South Norwalk, Conn.

Personal

Mr. W. M. Archibald has succeeded J. M. Turnbull as manager for the Consolidated Mining & Smelting Company of Canada, Ltd., at Trail, B. C.

Mr. F. K. Cameron, formerly of the U. S. Geological Survey, has been retained as chief chemist for the Utah Potash Co., which has acquired alunite deposits in Utah.

Mr. J. V. N. Dorr has returned to his New York office after an extended visit in San Francisco and Denver.

Mr. Harry A. Guess, engineer for the American Smelting & Refining Co., is on a professional trip in Chile.

Mr. J. E. Johnson, Jr., has been elected chairman of the New York Section of the Mining and Metallurgical Society of America.

Mr. Woolsey McA. Johnson is now consulting metallurgical engineer for the American Spelter Corporation, 61 Broadway, New York City, with works at Kusa, Okla. He is acting in an advisory capacity. The American Spelter Corporation makes a high-grade spelter, zinc 99.90 per cent or more, suitable for cartridge brass, and is now producing with a capacity of eight tons of virgin spelter per day.

Mr. Benjamin B. Lawrence has purchased the Pelton-Doble water wheel and the Pelton-Francis turbine which were exhibited by the Pelton Water Wheel Co. of San Francisco at the Panama-Pacific International Exposition and presented them to the Columbia School of Mines. Mr. Lawrence was a member of the class of '78.

Dr. John A. Mathews, general manager of the Halcomb Steel Co., Syracuse, N. Y., has been elected president of the company, succeeding Mr. H. S. Wilkinson, who has resigned.

Mr. L. H. Norton, of Silverton, Colo., has gone to San Francisco and will spend some weeks at Douglas, Ariz., before his return.

Mr. C. H. Vom Baur has taken charge of the sales in this country of the Rennerfelt electric furnace, of which Hamilton & Hansell, 17 Battery Place, New York, are exclusive agents.

Dr. J. A. Udden, geologist of the Bureau of Economic Geology, University of Texas, has been appointed Oct. 26, 1915, director of the Bureau, the former director, Dr. William B. Phillips, having resigned to become president of the Colorado School of Mines.

Captain Fred H. Wagner, chief engineer of the Bartlett-Hayward Co., Baltimore, Md., will deliver a lecture before the Franklin Institute, Jan. 6, 1916, on "Coal Gas Residuals."

Dinner to Director Van H. Manning of the Bureau of Mines

The staff of the Bureau of Mines and the staff of the U. S. Geological Survey tendered on Nov. 20, 1915, a complimentary banquet at Washington to Mr. Van H. Manning, the new director of the Bureau of Mines, in honor of his appointment.

Mr. E. W. PARKER, who acted as toastmaster, opened the proceedings with a silent toast to the memory of the first director of the Bureau of Mines, the late Joseph A. Holmes: "He gave all that he had."

Dr. GEORGE OTIS SMITH, director of the Geological Survey, was the first speaker, taking as his theme the U. S. Geological Survey as an institution of higher learning and its graduates. Among them he mentioned John Hays Hammond, who started thirty-five years ago as an assistant in the Geological Survey, and Herbert C. Hoover, who began his career twenty years ago as a geologic assistant. The Geological Survey has supplied eminent geologists and mining engineers not only to private corporations, but to the chairs of geology in many great universities from Cambridge to Palo Alto, to the geological surveys of many States, and to many celebrated scientific institutions. Van H. Manning is a graduate of the Geological Survey of the class of 1910. "While I cannot claim credit for the Geological Survey all that Director Manning is, I am glad that the rest of his career is to be credited to the Bureau of Mines. While all of us in the Geological Survey have taken great pride in the career of Topographer Manning and Chief Clerk Manning, we are now even more proud of Director Manning, and to him we pledge our heartiest support."

The toastmaster then read a note from Dr. HOWARD

KELLY of Johns Hopkins Hospital in Baltimore, expressing his regrets of being unable to be present:

"I hope this public recognition of your conspicuous services and recognized fitness for a great trust will but inaugurate a long, happy, and successful term of service. I cannot wish you better than that the mantle of the beloved Elijah may fall with increasing blessing upon the shoulders of Elisha. I love to think of your department, more even for the spirit of friendship and harmony prevailing there than for the great scientific work you are all doing."

Mr. SANFORD, editor of the Bureau of Mines, spoke for the bureau, sketching Mr. Manning's firm yet charming personality.

U. S. Senator THOMAS J. WALSH of Montana spoke in part as follows:

"A few evenings ago I opened a Bible that lay on my desk near my elbow, and, rather curiously enough without searching for it at all, I ran across the passage covering the temple of Solomon and the treasures of David which were stored therein by Solomon. The reflection would suggest that in this primitive day the earth had already given up so much of its metallic wealth that the time might come when we would see the earth's storehouse entirely exhausted.

"There is offered consolation in the fact, however, that as mining and metallurgy improve, deposits that under other circumstances were mere drops, are made available and that the percentage of the metallic extraction is continually increasing. By the best methods that were available to the Anaconda Copper Company at a period no more remote than three years ago, there was left in the tailings of its ore 0.70 per cent of copper. By treating these tailings now by the oil flotation process and by the modernized leaching process lately introduced, this loss has been reduced until now there is only 0.14 of 1 per cent of copper unrecovered, signifying a saving on every ton of ore treated by that company of 11.2 lb. of copper, which at current prices would amount to about \$2, or an added extraction by that company of a daily value of not less than \$25,000. By the substitution of electrical energy for steam power that company saves fifty cents per ton on every ton of the four million tons of ore that it treats annually. By this saving it is possible for that company to treat with a profit ore that carries five pounds of copper less than the lowest grade of ore that could be worked commercially before the more economic system was established and installed. Enormous amounts of low-grade ore in the Butte camp that heretofore could not be considered as a part of the company's reserve of that valuable metal have yielded enormous profits. An interesting peculiarity of that region is that the mineralization in past geologic ages was carried on so generously that very often the walls of the veins are utterly obliterated. The solutions carrying the metals penetrating through the adjacent country were such that they become ore as well as the veins, following, as a matter of course, the more remote from the main ore channels.

"So that under these improved processes and modern methods it is possible to mine a wider and wider body of ore in the neighborhood of almost all of the great ore channels in that camp, and for the same reasons the depth to which economic mining can be carried on has extended so that by the development of these processes and the installation of these new methods practically new and highly productive fields have been opened up as available just as though new deposits had been discovered. In the same way most of the great producing porphyries could not be worked at all except by the application of these new processes. The Utah Comper Company mines, mills, and markets its ore at a cost not to exceed \$1.25 per ton, and at that rate it can profitably treat copper ores carrying not more than 1 per cent of copper. It annually takes more than 150,000,000 lb. of copper out of a hole that twenty years ago was entirely negligible in any account that might be taken of the world's supply of copper ore. The Conrad Placer Company operates five great gold dredges in Alder Gulch. The fabulous richness of its ore gave rise to the first stampede to Montana. The enterprise was started by Professor Shaler of Harvard. At its inauguration steam was used for power with such meager results that it was scarcely able to make expenses. In after years they have operated with electricity, with the consequence that they have been reaping such profits that they have cleaned up the entire gulch.

"Montana is to-day indeed a great factor in the production of zinc, not because of any new discovery at all, but because processes have been developed within the last three or four years under which refractory ores might be suc-

cessfully treated. As has been suggested here this evening, the world's wealth in agriculture under wise husbandry has experienced no diminution, but the world is suffering constant exhaustion with respect to its mineral wealth. I am advised that the great steel companies are making provision against the day of a dearth of iron ore in this country by securing large deposits in Chile and Cuba. In my opinion, the prime object of the existence of the Bureau of Mines is the conservation of the lives of the men who toil in the mines. And next to that is the conservation of our mineral wealth by making available to man the deposits which, although known, are unworkable at this time. Might I be pardoned for suggesting that the most intimate kind of relationship ought to be cultivated between the Bureau of Mines and those who are actually engaged in carrying on the business of mining. We may rely upon the ingenuity and the enterprise of the mining engineers to apply known processes and recognized methods to the treatment of ores that will render a profit, but we must rely upon the researches of the Bureau of Mines for the development of new processes. They must find the key that will unlock these locked treasure houses and place their great deposits at the service of mankind. Friends of the Bureau of Mines indulge in the expectation that it will meet every reasonable hope that may be entertained for it under the capable management of Mr. Manning, worthy successor to Dr. Holmes, who was loved, respected, and admired by all who were fortunate enough to know him in life."

Mr. J. E. CALLBREATH, secretary of the American Mining Congress, spoke of the history of the establishment of the Bureau of Mines, and advocated most generous treatment on the part of the Federal Government.

Secretary FRANKLIN K. LANE said it had been a matter of very great pride to him "to be identified with a department which has in its service men of such large information and ability and such self-sacrifice as some of the chemists and engineers we have in the Bureau of Mines." He mentioned Rittman, Parsons, Moore, Cottrell. "It is a great pleasure for me to stand here and speak with such appreciation of the men who are in this department and who are doing the kind of work that has not been done in the United States before, and as Edison outdid the rest of the world in invention, so we will outdo the rest of the world in chemistry, though we are but babies now."

In verses of Kipling Secretary Lane paid a tribute to the late J. A. Holmes, and concluded:

"Mr. Callbreath spoke of safety first. I rather like the toast of the President, 'America first.' And these two are one and they are linked together in the Bureau of Mines and what it stands for. Safety for ourselves and safety for our country—the pre-eminence of our country. And what is to stop our country from being pre-eminent when we have the men who can find out the secrets of nature, and having reserved more of this foundation material which goes to make a great industrial people of our or any other nation, because we have passed now into an industrial world and war seems to be the chief industry? At least, it is an industry by itself and to-day it is being conducted as an expression of the most intense industrial life. There was a time when a war was just a meeting of a lot of men with swords, and then they sang to the man who made the sword. But the sword plays no part to-day. Down at the bottom it means immense mineral reserves from development and from most intensive use. Barbed wire, mechanics, chauffeurs, railroads, cannon, high explosives, automobiles, everything that a great industrial nation has, constitutes the army now when comes the war, and we are an army pre-eminently great in leading any onslaught, because we have mineral resources greater than those of any other country.

"We can build a battleship out of the mines of the United States, and no other country can make that boast. And it is the plan to make the Bureau of Mines a great conservation institution, saving from waste, putting in use; and I have no doubt but that the President was wise, as wise as usual, when he selected to direct the work of that bureau, Mr. Manning."

Mr. VAN H. MANNING replied in part as follows:

"There has been more or less discussion as to who is responsible for the propaganda of 'Safety First.' The Bureau of Mines has never claimed responsibility for the safety-first movement in the mines, but it has very properly

claimed the responsibility for the national movement. . . .

"I wish it were possible for me to speak to you from the fullness of my heart, but this is impossible. The inspiration of this scene, surrounded as I am by friends, old and new, rejoicing with me, is a strong incentive to a renewed courage in the performance of my duties as Director of the Bureau of Mines. The Director of the Bureau of Mines has been entertained from the Atlantic to the Pacific Coast, from the Great Lake on the North to the Mexican boundary line. These entertainments were given in honor of the officer, but to-night it is the man that you honor by your presence.

"One of the mottoes which I have followed through life has been said: 'He who does the best his circumstance allows, does well, acts nobly. Angels could do no more.' I have been commended for the loyalty I have always maintained to those to whom I am responsible for my work. I would have it said of me: 'His loyalty is e'er the same, whether it is to lose or win the game.' I have been on both sides of the game, having won and lost through my loyalty to a cause I felt to be just.

"I want your friendship among the material things of life, and to make my administration successful I must retain it. I am grateful to the President of the United States for my appointment as Director of the Bureau of Mines; grateful to the Secretary of the Interior, who has assumed great responsibility in my appointment, and grateful to you for the confidence you have expressed in me to-night by assembling here to do me honor.

"When the day is done, I will be satisfied if it is said of me: 'Living he did gain men's good opinions; and now dead leaves his work to the care of noble friends.'"

Obituary

Charles H. Kiessig died at his home in New York City at the age of 65 years. He was born in Leipzig, Saxony, and came to the United States in 1879 to establish the manufacture of ultramarine blue. For the last twenty years he conducted a business as importers' agent. He was well known and universally liked in chemical and paint circles, but his friends in the chemical fields will probably best remember him for the forgotten smokers on Saturday nights in the old Chemists' Club in Fifty-fifth Street, which he arranged in his quiet, genial manner while chairman of the house committee of the Chemists' Club for several years.

Book Reviews

Mechanical Drawing for Colleges and Universities.

By James D. Phillips and Herbert D. Orth. 284 pages, 295 illustrations. Price, \$1.75. New York and Chicago: Scott, Foresman & Co.

A similar book for high schools is to be issued by the same authors, the two books to constitute a complete course. This work, however, seems fairly complete in itself; it lays out a graded course very suitable for college students, with the many practical points and details carefully worked out. The two books together should find a wide use, where the high school can be induced to co-operate to that extent with the college or university. The publishers announce that this is one of their vocational series intended for use in the vocational courses that are now becoming so large a part of public education. Prof. F. D. Crawshaw, of the University of Wisconsin, is editor of the series.

Laboratory Work for Coal Mining Students. By J. Sim and A. M. Wylie. 4¾ x 7¼ in., 136 pages, 17 cuts. Price, 90 cents. London: Edward Arnold.


A useful little book, well adapted to its purpose. The five chapters concern coal analysis, washing and coking tests of coal, testing of oils, gas analysis and fan tests. While the contents appear well written and useful to coal miners, yet methods of testing the average velocity of air in a gallery or shaft and the ignition point of various mixtures of coal gas and air would appear to be subjects that should not have been omitted, even in a most elementary course.

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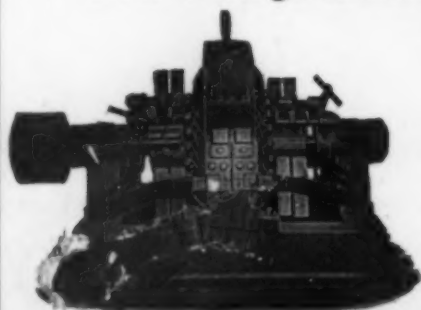
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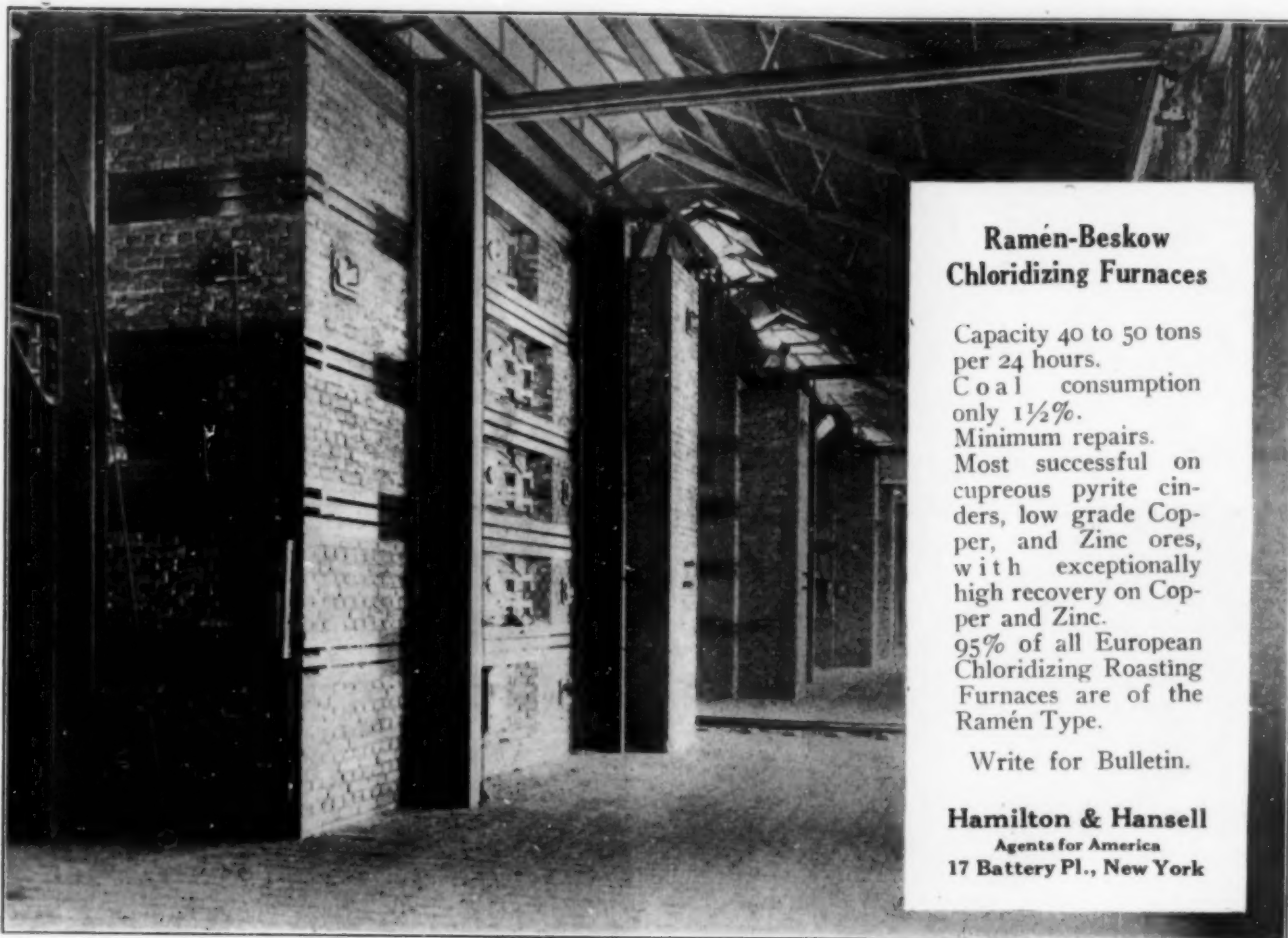
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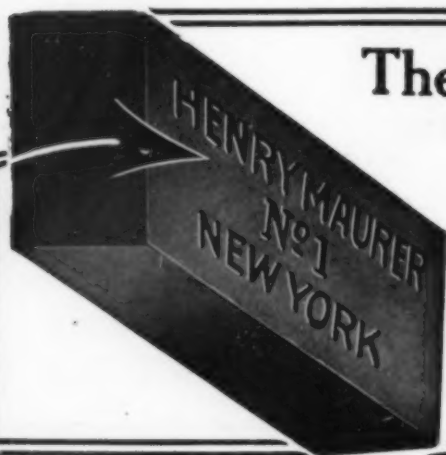
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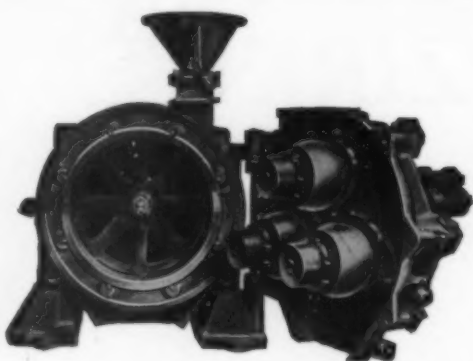
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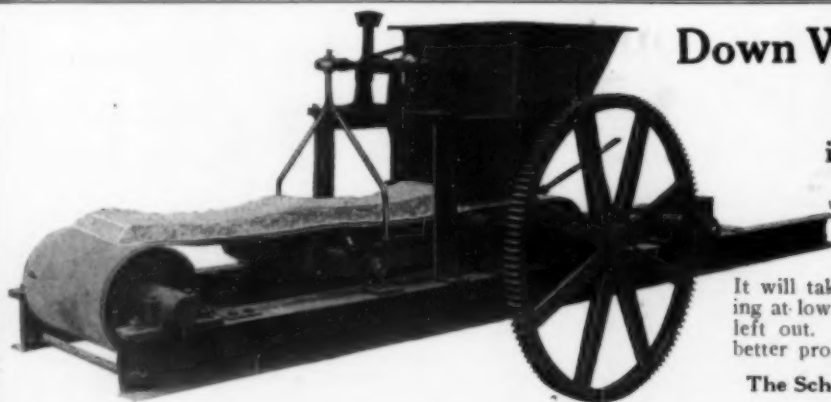
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We build **Crushers** of several types (Jaw, Rotary and Hammer) for coarse or fine reduction. **Rolls** for fine crushing and Granulation—Ring-Roll, Hammer Bar, Swing Hammer and Emery Mills for coarse, intermediate and fine grinding.

Newaygo Screens and Separators for all kinds of screening; Laboratory Crushers, Rolls, Grinders and Screens for Sampling; Coal Crushers and Automatic Samplers—Automatic Scales, Dry Mixers, etc.

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if you install the

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It will take care of your compounding and mixing at low cost, with the fallible "human element" left out. At the same time it will give you a better product. Let us prove it. Write us today.

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Tiffin, Ohio, U. S. A.



Most Economical Grinding

FROM RESULTS OBTAINED BY OUR CUSTOMERS WE ESTIMATE THE CAPACITY, AS FOLLOWS, OF THE

MAXECON MILL

Limestone	4 tons per hour to 95% 100 mesh
Florida Pebble	7 tons per hour to 90% 60 mesh
Bauxite	4 tons per hour to 95% 100 mesh
Hardest Ores	5 tons per hour to 90% 50 mesh
Coal	4 tons per hour to 95% 100 mesh
Silica	2 tons per hour to 95% 200 mesh
Cement Clinker.....	10-12 bbls. per hour to 98% 100 mesh

With Under 25 H. P. Minimum Wear and Repairs

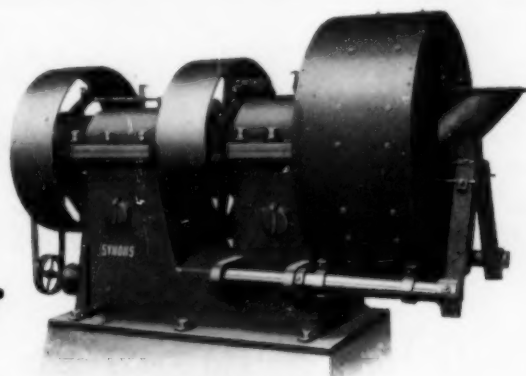
Used as a Standard Grinder by the United States Steel Corporation, Aluminum Company of America, Pennsylvania Salt Manufacturing Company, Virginia Carolina Chemical Company and practically universally in the chemical fertilizer factories of the United States and Europe. Send for Bulletin 36.

KENT MILL CO.,

NEW YORK, Borough of Brooklyn, 10 Rapelyea St.
BERLIN, Berlin-Hohenschönhausen.
LONDON, 31 High Holborn.

The Symons Disc Crusher

Four Sizes



Successfully reduces wet or dry ore to smaller product.
Quickly adjustable to any standard size of product down to $\frac{3}{8}$ inch.

Takes rejections from standard gyratory crushers and reduces same to $\frac{3}{4}$ -inch size and less.

Spreads while crushing, thereby avoiding congestion.

Ten additional reasons for its success. All enumerated in Bulletin B.

SOME Rock-crushing Economy, thus:

Record of 48 in. Symons Disc Crusher for a period of approximately 11 months:

Operating labor	\$0.00214
Repair labor .....	.00205
Material for repairs .....	.00280
Power .....	.00899

Total	\$0.01598
Less extraordinary items .....	.00228

Cost under normal conditions .01370

No. 1 Crusher ran 4,392 hours and crushed 197,640 tons of ore. One pair of discs ran 3,453 hours, crushing 155,385 tons at cost of \$0.0014 per ton for discs.

No. 3 Crusher ran 4,462.5 hours, and crushed 200,812.5 tons ore. One pair discs ran 4,462.5 hours, crushing 200,812.5 tons at cost of \$0.00109 per ton for discs.

Crushers handled 45 tons per hour, crushing 3 in. to $\frac{7}{8}$ in. and requiring 35 horsepower each.

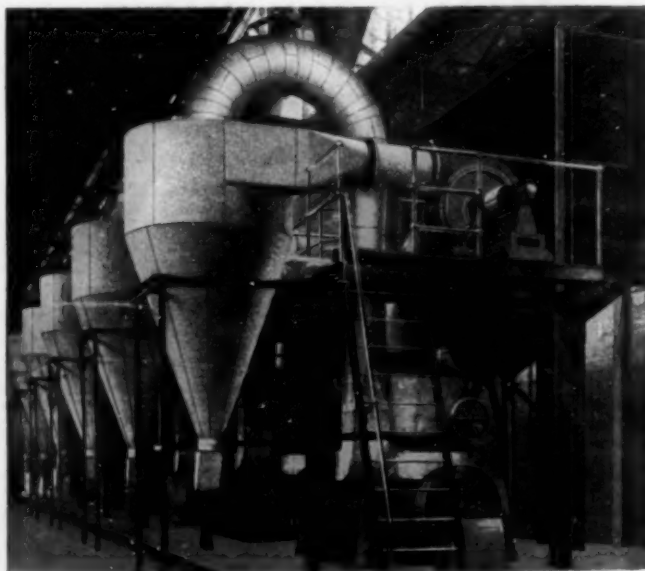
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New York Office
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The Service You Secure from the



Raymond System as installed in a Cement Plant for grinding raw material or coal

RAYMOND PULVERIZING AIR-SEPARATING SYSTEM

is a good deal more than the mere service of good machinery.

In the first place we never make an installation without a thorough knowledge of the conditions present in each case. We couldn't afford to do so because we make a rigid guarantee of specific results in every case.

And that is a big element of service in itself.

Furthermore, the Raymond System is not a machine—it is a *method*.

Different conditions require different adaptations of method for securing the most efficient and economical results.

Our engineers are in constant touch with development in all lines and consequently we are able to furnish our customers a service of great value not only in the planning of the best adaptation for their particular needs before installation, but also in improvements of operation after installation which will increase efficiency.

Remember that the Raymond System is being used in more than 350 plants for the reduction of more than 75 different materials of widely varying character.

Ask for our book.

We design special machinery and methods for Pulverizing, Grinding, Separating and Conveying all powdered products. We manufacture Automatic Pulverizers, Roller Mills, Vacuum Air Separators, Crushers, Special Exhaust Fans and Dust Collectors.
SEND FOR OUR BOOK.

CUT OUT THIS COUPON
As a Reminder to Write

Raymond Bros. Impact Pulverizer Co.

1305 North Branch St., Chicago

about the Raymond System of Grinding and Separating

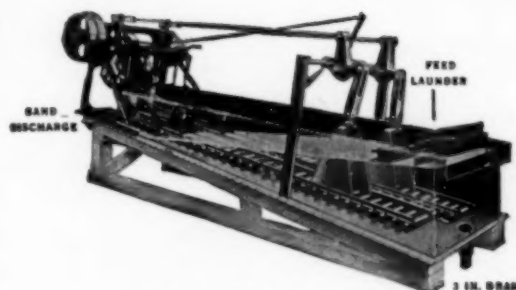
Do You Want a Coarse or Fine Separation for Flotation or Cyanidation?

The DORR CLASSIFIER

will give you a separation at 48, 60, 80, 100, 150 or 200 mesh.

At the ANACONDA MILL requiring 60 mesh separation **fifty-three** Dorr Classifiers are now in use.

The INSPIRATION are now operating **eighteen** Dorr Classifiers for 48 mesh separation; an additional shipment of **eighteen** machines has been made for the same purpose.



The Dorr Classifier (Patented)

THE DORR CYANIDE MACHINERY CO.

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Your Fine Ores, Concentrates, Fluedust can be cheaply and successfully sintered by the

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SIMPLE—EFFICIENT—LOW FIRST COST

Large installations are in continuous daily operation in many smelting plants of our Licensees in United States, Canada, Mexico, Australia and Europe. For particulars and estimates address:

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(SUCCESSOR TO DWIGHT & LLOYD METALLURGICAL CO.)

CABLE ADDRESS: SINTERER—NEW YORK

Special Agents for Iron Ores: American Ore Reclamation Co., 71 Broadway, New York

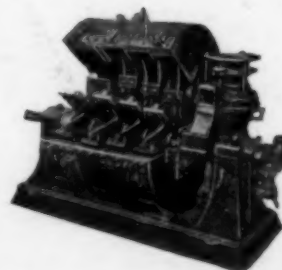
BURN PULVERIZED COAL BY THE AERO SYSTEM

BECAUSE

1. It gets every available B.T.U. out of the coal.
2. Makes available slack coal and screenings at a fraction of the cost of mine run and lump coal and oil.
3. Eliminates the danger of fire or explosion from fuel in storage.
4. Both temperature and quality of flame accurately controllable at all times.
5. Construction prevents clogging by obstructions and guarantees continuous dependable action.
6. Perfect combustion is effected—No soot—no smoke, no free oxygen, no CO.

Shall We Send "Real Evidence"?

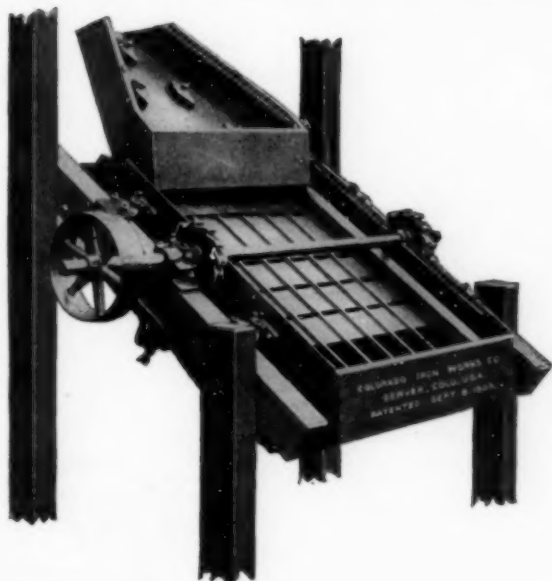
AERO PULVERIZER CO., Equitable Bldg.,



NEW YORK



Look to the Knowing Ones for Guidance



Large, low operating cost mills are the most exacting in their requirements with respect to every item of equipment. They have tried many machines and they know the best. A list of users of the

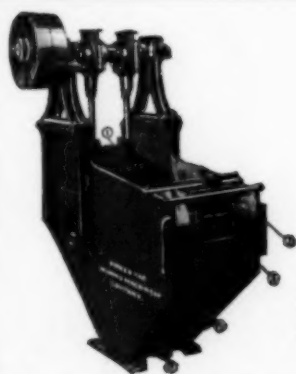
Impact Screen

reads like a list of the most successful mills in operation. The list is long, but it starts like this:

Utah Copper Co.
Ray Consolidated Copper Co.
Chino Copper Co.
Braden Copper Co.
Butte & Superior Copper Co.
Timber Butte Milling Co.

But you don't have to be big to profit by the Impact Screen, and so, not to be overlooking what might be a good thing for you, why not write for information about it?

Colorado Iron Works Co.
Denver, Colo., U. S. A.



Woodbury Slime Classifier

You could not expect more from one self-contained machine

- 1st Unclassified mixed feed entering over plunger compartment.
- 2nd Dense slime approximately 60 mesh and finer.
- 3rd Tailings free of slimes for further treatment.
- 4th Clean cup concentrates automatically discharged.
- 5th Clean hutch concentrates.

The largest mills in the country are daily making the separations outlined above. We will be glad to advise you of its ability to treat your ore, whether it be copper, iron, silver, lead, zinc, or any material that can be separated by specific gravity.

PRINCIPAL PRODUCTS—
Rock Crushing Machinery.
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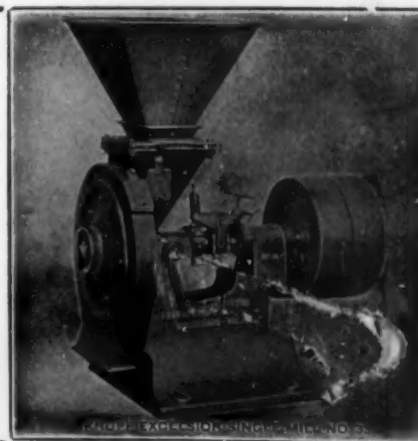
M276.2

Krupp Machinery and Products

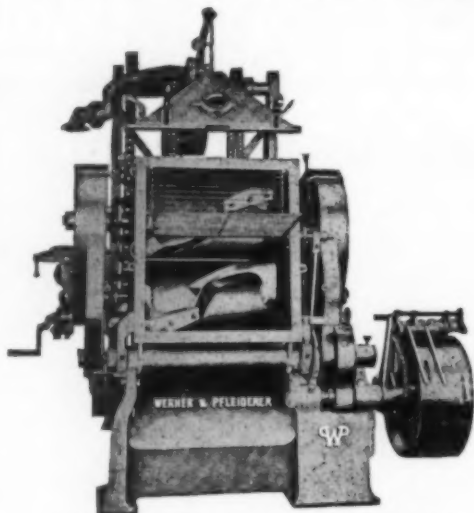
BALL MILLS EXCELSIOR MILLS
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FORGINGS OF ALL QUALITIES OF STEEL
SPECIAL MACHINERY OF ALL CLASSES

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Vacuum Kneader—Interior view with cover raised

wherever masticating, mixing, kneading, incorporating and pulping is required.

By our wide experience extending over many years in the building of such machines we are able to handle advantageously practically all kinds of such propositions.

Inquire concerning our
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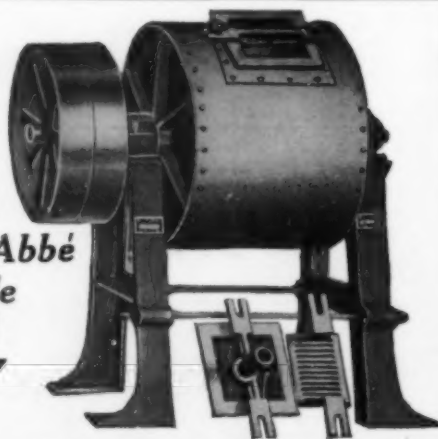
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The
Paul O. Abbé
Pebble
Mill
No. 7



**These Pebble Mills will
 Not Discolor the Material**

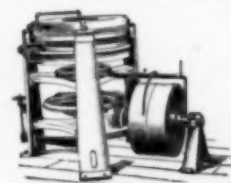
Paul O. Abbé's Mills are lined with a thoroughly vitrified porcelain brick set in cement. There is no contamination of the material being reduced. Special linings of Silix Brick furnished if desired.

Profit by Paul O. Abbé's 20 years of equipment building. It will solve your grinding and crushing problems. **WRITE FOR THE NEW CATALOG.**



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 and Sifting Machinery
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Improved Lead and Paste Mill

Disintegrators, Dryers
 Chasers and Machines for

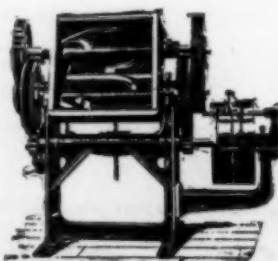
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Office and Factory: Cincinnati, O.

Write for Catalog
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 line of Mills and



Giant Kneading and Mixing Machine

MIXING MACHINES

For Rapid Thorough, Uniform Mixing— Broughton Mixers

Here are some of the
expressions of users:

"The Mixer is very strong and thoroughly incorporates the ingredients."

"The expense for repairs is almost nothing."

"Has speed and facility of disposing of the mixed product."

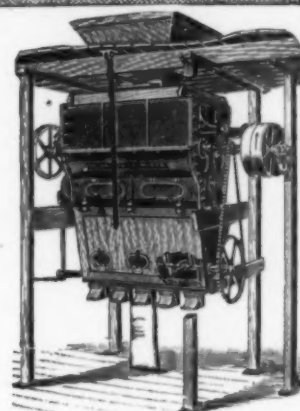
"A strong, well-built and thorough mixing

machine."

After two years of use—"As good as the day it was installed."

"A very efficient machine, which paid for its cost in a very short time."

"The work in our plant is very heavy and your Mixer has stood the work perfectly."



Get the statements of other users from our Catalog. Send for it **today**.

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SYRACUSE, New York

AIR COMPRESSORS

We have the following air compressors in Denver ready for immediate shipment. These compressors are in practically as good condition as when new. Most of them have not been in use six months. You can save 50% over the cost of new.

NORWALK COMPRESSORS

14 x 26 steam, 22 x 13 air, 24 stroke. Capacity 1160 ft., Corliss valve on low pressure steam.

14 x 16 x 9½ x 16 compound air simple steam. Capacity 558.

10 x 12 x 6½ x 12 compound air simple steam. Capacity 282.

We have three of this size.

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8 x 10 x 12 Rand Class C. Capacity 153 ft.

14 x 14 x 22 Rand Class C. Capacity 391 ft.

14 x 16 x 22 Rand Class C. Capacity 512 ft.

16 x 18 x 24 Rand Class C. Capacity 671 ft.

9½ x 12 x 8½ x 12 x 12 Rand Class B3. Comp. air and steam. Capacity 282 ft.

11 x 18 x 18½ x 10½ x 10 Ingersoll Class G2. Comp. air and steam. Capacity 439 ft.

24 x 14 x 24 x 13 x 16 Rand Imperial Type 10. Comp. air and steam. Capacity 1250 ft.

LAIDLAW - DUNN - GORDON COMPRESSORS

6 x 8 x 6 simple steam and air comp., 52 ft. capacity.

8 x 14½ x 8 x 8 Duplex steam comp. air, capacity 345 ft.

12 x 20 x 11 x 12 Duplex steam comp. air, capacity 520 ft.

10 x 18 x 10 x 10 Duplex steam comp. air, capacity 588 ft.

LEYNER COMPRESSORS

8 x 9 x 12 simple steam and air, capacity 130 ft.

12 x 13½ x 8½ x 16 comp. air simple steam capacity 314 ft.

16 x 18 x 11 x 22 comp. air simple steam, capacity 648 ft.

FRANKLIN COMPRESSORS

9 x 11 x 11 simple steam and air comp. Capacity 193 ft.

10 x 12 x 12 simple steam and air comp. Capacity 236 ft.

AMERICAN COMPRESSOR

12 x 14 x 16 simple steam and air. Capacity 342 ft.

BELTED COMPRESSORS

6 x 6 Curtis vertical Duplex. Capacity 48 ft.

10 x 12 Rand Imperial Type 11. Capacity 196 ft.

16 x 10 x 18 Leyner Comp. Air. Capacity 481 ft.

10 x 10 x 12 Laidlaw Comp. Air. Capacity 525 ft.

18 x 10 x 10 Clayton Comp. Air. Capacity 588 ft.

24½ x 14½ x 14 Ingersoll, Class J2. Capacity 1007 ft.

AIR RECEIVERS

2—48 x 10, 6 inch opening. Weight 2350 lbs.

7—42 x 10, 6 inch opening. Weight 1700 lbs.

1—42 x 12, 6 inch opening. Weight 2000 lbs.

1—30 x 10, 4 inch opening. Weight 950 lbs.

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Every size and make of Piston Drills, \$75.00 each.

40—New Murphy Stopping Drills, \$50.00 each.

5—New Murphy Mining Drills, \$40.00 each. Columns, arms, comp. pipes, etc.

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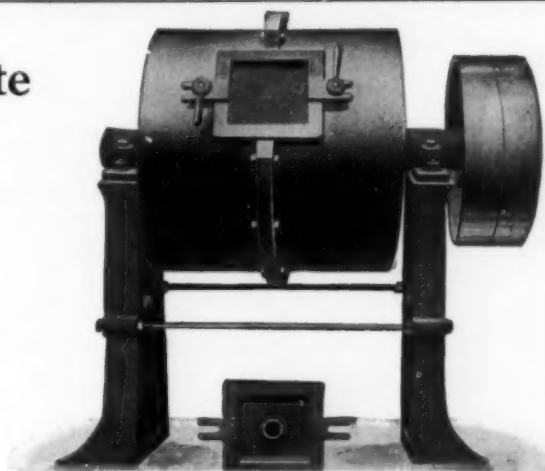
Grind, Crush and Comminute at Less Cost

Our improved machines will effect important **economies** in your work in three ways:

They require **less expert attention**.

They are practically **trouble-proof**, and thus **eliminate shutdowns** for extensive repairs.

The resulting product is of a **finer** and more easily marketable character.



Abbé Pebble Mill

Abbé Tube Mill.

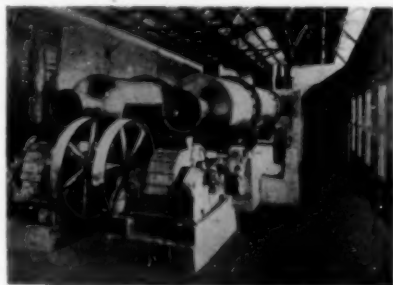


Talk it over with our Staff

Our laboratories and 35 years of engineering experience are at your service without cost. We want you to learn the possibilities of improvements in your work.

We build and constantly carry in stock Ball Mills, Pebble Mills, Jar Mills, Cutters, Crushers, Laboratory Mills, Disintegrators, Pressure Blowers, High Vacuum Pumps, Vacuum Heating Pumps, Mixers, Sifters. Send for illustrated Bulletins.

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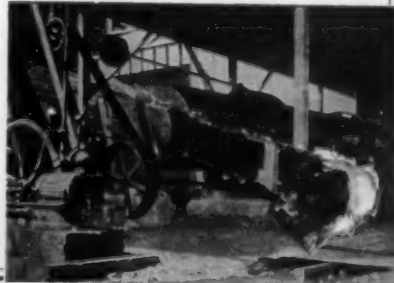
Indirect—Direct—Steam
Require Less Power—Dry More Quickly
Troubleproof—Low in Ultimate Cost.

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1 lb. = 2½ lbs. Sal. Soda

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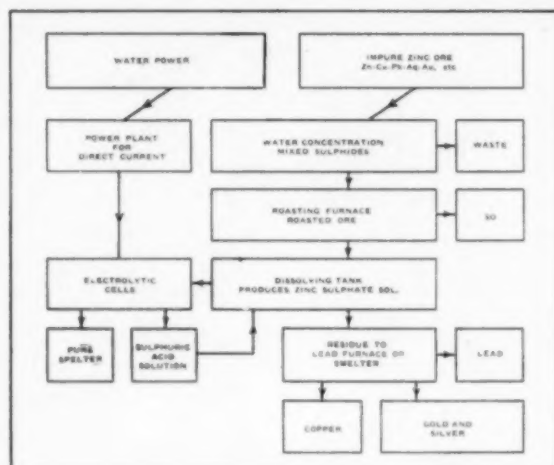
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The Process Engineering Co.

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Philadelphia, Pa.

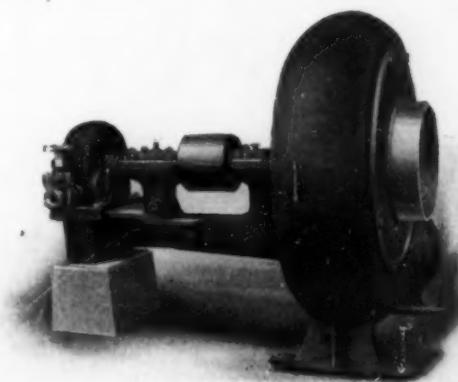
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Builders of

**High Explosive
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**WILLIAMSPORT, PA.
U. S. A.**



Ventilation of Chemical Works

requires equipment that is reliable in operation and simple in construction. The Pelton system of ventilation is especially suited for chemical industries, because—

All parts can be made of corrosion resisting materials.

It is moderate in first cost.

It is easily installed.

Replacement parts are inexpensive and quickly put in place.

The Pelton system of ventilation consists of a small water motor direct connected to a fan, and can be used wherever water under a pressure of 30 pounds or more is available. May we tell you more?

The Pelton Water Wheel Company

2187 Harrison St.
San Francisco, Cal.

87 West St.
New York, N. Y.

U. S. Government Tests of Monel Metal

Value Under Severe Conditions Proved For Important Uses



IT is a striking commentary on the qualities of Monel Metal that the United States Government continues its use on a large scale. For various fittings in marine construction—high pressure and superheated steam apparatus, valve seats, valve stems, pump rods, etc.

—Uncle Sam is an extensive user of this non-corrodible alloy that has the strength of steel.

Monel Metal is playing an important part at the Panama Canal, where the government is leaving nothing undone to secure perfection in mechanism and durability. In a huge floating Caisson recently built for repairing or painting the massive lock gates, Monel Metal was specified by the Canal Commission for all inlet and outlet valves—valve stems and valve cages. More than 20,000 pounds of the metal for this one order alone were supplied by the Supplee-Biddle Hardware Co.

Monel Metal, repeatedly tested by Government engineers, has always showed satisfactory strength in addition to extreme non-corrodibility. Recent tests, prior to our filling the order for the Canal Caisson, proved the qualities of the metal to be higher than the Government requirements. We are showing on this page the results of two of these tests and ask the reader's scrutiny of the actual photographs which are here reproduced with *no retouching whatever*.

Any information on Monel Metal will be gladly furnished if you write us. Send us your name and we will put you on the mailing list of "The Supplee-Biddle Bulletin," a monthly publication devoted to Monel Metal.

Supplee-Biddle Hardware Co.

Manufacturers

512 Commerce St., Philadelphia 343 Hudson Terminal Bldg., New York
BRANCH OFFICES: London Montreal Stockholm Buffalo



U. S. Government Tensile Test. Monel Metal Casting showing homogenous break and stretching of material before the break.

.505" diameter cut from 1" square casting.

Elastic Limit per sq. in. 31,800

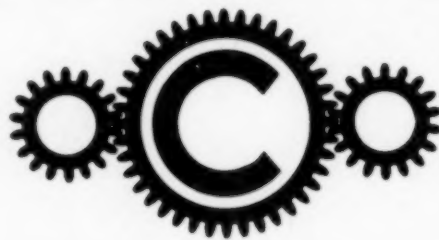
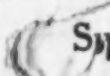
Ultimate Strength per sq. in. 79,600

Elongation in 2" 42%

Reduction of Area 39.3%

Castings made in Philadelphia plant of Supplee-Biddle Hardware Co.

U. S. Government Tensile Test. Monel Metal Hot-rolled Rod, .505" diameter, cut from 1" rod. Elastic Limit, per sq. in. 50,000 Ultimate Strength per sq. in. 89,150 Elongation in 2" 36.0% Reduction of Area 67.9%



Why Make Patterns?

Whether you want one gear or one hundred, why go to the expense of making patterns? We can furnish you machine molded gears and save you pattern expense.

By the Machine Molding Process all the teeth in a gear are molded from a single tooth pattern, the spacing being done by accurate machinery.

A machine molded gear is, therefore, more accurate, better balanced and as nearly perfect as a cast tooth gear can be made.

SPUR, BEVEL, MITER and WORM GEARS machine molded—1" to 6" pitch.

MORTISE WHEELS with dressed teeth and cogs. We are equipped to furnish gears with *Machine Cut Teeth*.

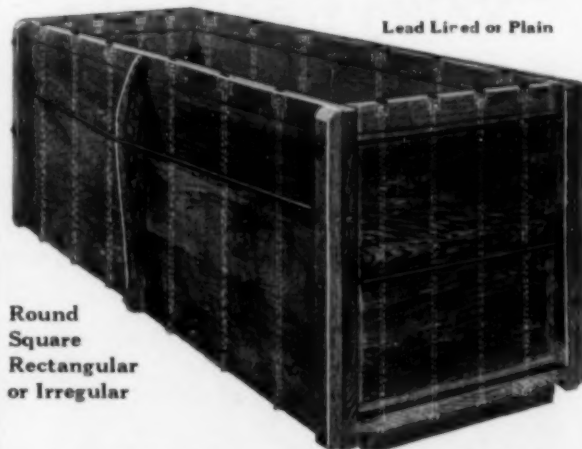
Our No. 38 catalog lists the gear you want. Over 100 pages of gear lists and useful information. Have you a copy?

H. W. CALDWELL & SON CO.

17th Street and Western Avenue Chicago
50 Church Street, New York

QUALITY INSURES ECONOMY Especially in the case of WOODEN TANKS

Lead Lined or Plain



Round
Square
Rectangular
or Irregular

The man that takes into consideration Service Giving Material, together with Quality of Workmanship

BUYS "Hauser-Stander" TANKS

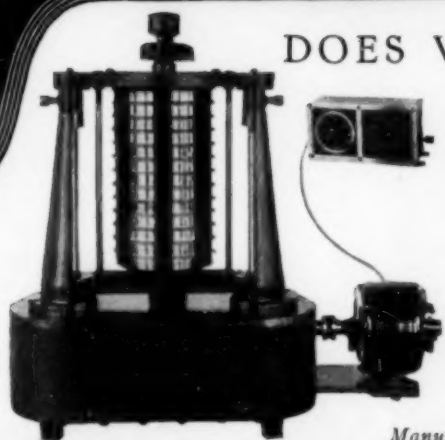
If we cannot convince you with pictures and quotations; buy a Hauser-Stander Tank and let the Tank convince you of its real value.

Our tanks in time will save you money
We win with quality

The Hauser-Stander Tank Co.
Cincinnati, Ohio



DOES WORK OF SEVEN MEN



The RO-TAP Testing Sieve Shaker will make tests on seven different samples with one run of the machine. The Stop-Rite Time Switch times the tests accurately. The RO-TAP Testing Sieve Shaker and Stop-Rite Time Switch mean uniform sieving action and accurate timing, insuring dependable, comparable results.

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and
prices

THE W. S. TYLER COMPANY
CLEVELAND, OHIO

Manufacturers of the Tyler Double Crimped Wire Cloth and Mining Screen



"Here is Our Car Problem"
said a big Chemical Company

We solved it!

They wanted cars to handle a very finely pulverized material, without leakage or waste. They consulted our car experts and secured both the cars and a transportation system of the highest possible efficiency.

EASTON CARS will meet your Car Requirements

Now—when chemical plants *must* work at top notch efficiency—is no time to experiment with industrial cars. We offer the results of 25 years' car experience, and facilities for rapid production at low prices toward the filling of *your* car needs. *Cars of all kinds*—either supplied promptly from stock or built to order. Complete industrial car layouts designed and manufactured from your drawings. Get all the facts by sending coupon for our Catalog 508A. Address Dept. A.

Easton Car & Construction Co.
Easton, Penna.
General Sales Office: New York



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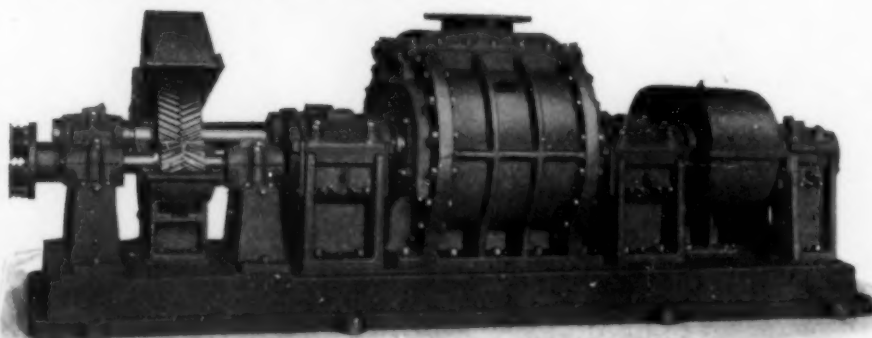
Easton Car & Construction Co.
Easton, Pa.

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No. 508A

Name

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For Filtration



*Simple—Accessible—
Interchangeable
Main Bearings*



Blowers for Flotation

Built to any capacity
and drive requirements.

Send for Catalog 48

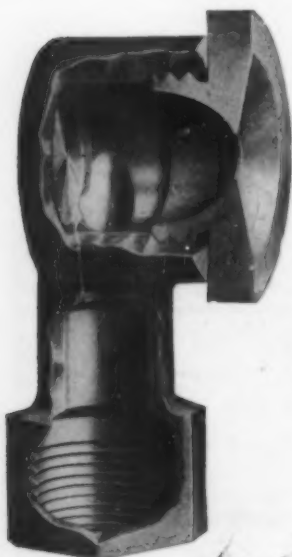
ROTARY VACUUM PUMP

NEW YORK
120 Liberty St.

P. H. & F. M. Roots Co.
CONNEERSVILLE, IND.

CHICAGO
1245 Marquette Bldg.

The Buffalo Spray Nozzle



—for cooling ponds
—for washing and cooling air

Wherever cooling ponds are used for cooling water for condensers, transformers or water jackets, Buffalo Spray Nozzles should be the choice because—

—they give a fine spray on minimum water pressure (15 lbs.).

—the atomizing effect is obtained with large water passages, thus securing freedom from clogging.

—the nozzle is made in only two parts.

These advantages of construction make Buffalo Spray Nozzles equally valuable in washing and cooling air for electrical machinery.

Write for the data on spray nozzle uses. It may point the way to improvements in your work.



Manufacturers of Air Washers, Spray Nozzles, Blowers,
Forges, Drills, Engines, Heating and Ventilating and Drying Apparatus

Buffalo Forge Co. Buffalo N.Y.

The Simplest Air Compressor and Vacuum Pump

Here are the Reasons

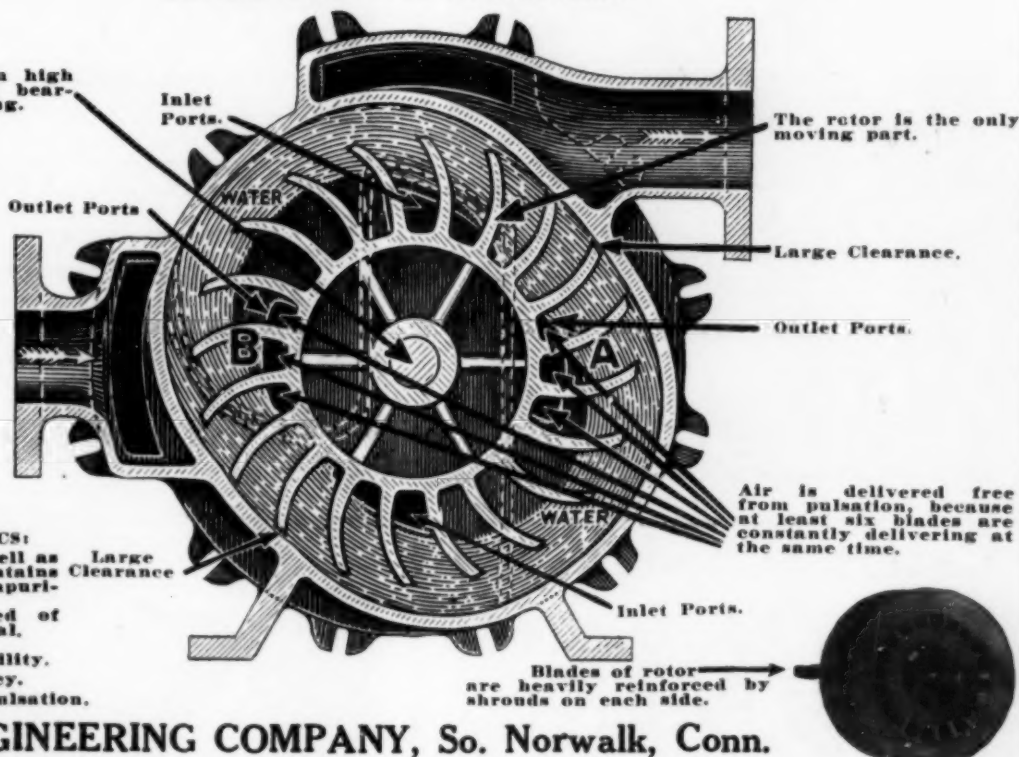
Shaft is mounted on high grade annular ball bearings outside of casing.

Note the total absence of valves, pistons, rods, crank shafts, loose vanes and gears.

Side thrust is eliminated because compression takes place simultaneously on opposite sides of the rotor (at A and B).

CHARACTERISTICS:
Air is washed as well as compressed, and contains no oil or other impurities.
Can be constructed of Acid-Resisting Metal.

Absolute Reliability.
High Efficiency.
Delivery without pulsation.



NASH ENGINEERING COMPANY, So. Norwalk, Conn.

A "Sirocco" or a rotary blower?

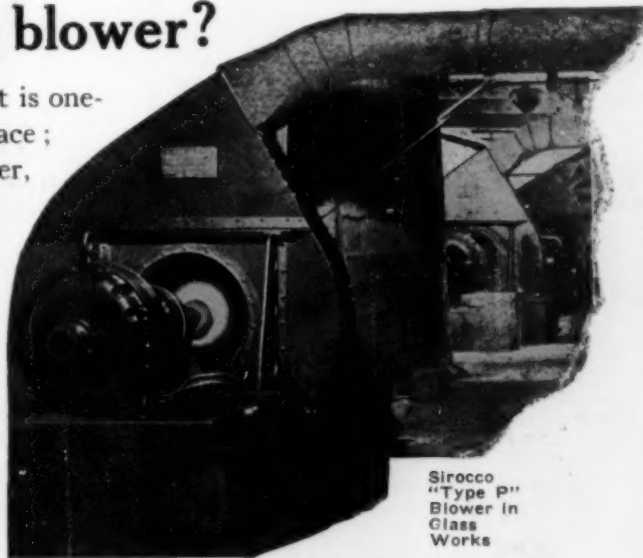
A "Sirocco," of course, BECAUSE its cost is one-third; it occupies one-third the floor space; costs less to maintain; requires less power, and gives constant pressure!

"Sirocco" Type "P"
TRADE MARK.

FAN TYPE DIRECT-CONNECTED BLOWER

is manufactured for the wasteless operation of blast furnaces; forge shops; cupolas; smelting, refining and sintering plants; glass works and all other kinds of metallurgical and chemical works in which blowers are adaptable.

By being directly connected to the prime mover, the "Sirocco" eliminates worn gears which cause loss of transmission. Further, it has no impellers to wear from rubbing, which means no air leakage. It is just as perfect after five years' operation as the day of installation. If you have an inefficient rotary now, why not dispose of it? To waste money, power, and floor space is not being economical. Write today for our Bulletin No. 8025 and list of installations.



AMERICAN BLOWER COMPANY, DETROIT, MICH.

Canadian Sirocco Co., Limited, Windsor, Ont., Manufacturers for Canada



Carrier Cooling and Drying Apparatus in a Candy Factory

Here is the story better than we could tell it ourselves:

"We have used Carrier Apparatus for three years for refrigerating our chocolate packing and stock rooms during warm weather and are greatly pleased.

"We have no automatic control for the temperature but easily keep it within five degree range during the day, which is sufficiently close. The humidity remains practically constant, sufficiently low to prevent discoloration of the coating of our goods, at the same time not low enough to discomfort employees.

"In our former refrigeration plant air was blown directly across expansion coils and we introduced fresh air at intervals to secure good ventilation. We do this also with present apparatus, but are able to keep the air much sweeter and cleaner and the humidity much more constant.

"Of course we also introduced fresh water in our spray system at very frequent intervals and this itself proves that we are removing much dust and impurity from the air of the rooms."—G. H. Bunton, Pres., The George Close Co.

Manufacturers requiring cleanliness, or fixed temperature or humidity or any combination of these for most and best production, are missing a great opportunity by not getting Carrier advice and Carrier apparatus.



Tell us your conditions and we'll tell you why.

Carrier

Engineering Corporation

385 Grand St., New York

Boston, Mass.
176 Federal St.

Philadelphia
Land Title Bldg.

Buffalo, N. Y.
Mutual Life Bldg.

Chicago, Ill.
Transportation Bldg.

18

Save your employees and equipment from the harmful effects of a DUST LADEN ATMOSPHERE. Increase the EFFICIENCY of your plant by creating a CLEAN, WHOLESOME ATMOSPHERE.

EXHAUST THE DUST

and save your exhauster by installing a

MORSE RAREFIED DUST COLLECTOR



The dust is removed before the air reaches the fan. The GREAT EFFECTIVENESS OF THE "MORSE" WILL MAKE YOUR FAN LAST INDEFINITELY. YOU'LL FIND IT A HIGH GRADE INVESTMENT.

BUILT ANY SIZE— ANY CAPACITY

If you have some problem for saving waste, improving working conditions, correcting unsatisfactory methods or economizing in operation we would like to mail you our catalog.

The Knickerbocker Company
Park Place
Jackson, Michigan

S & U Centrifugals Expedite Laboratory Work

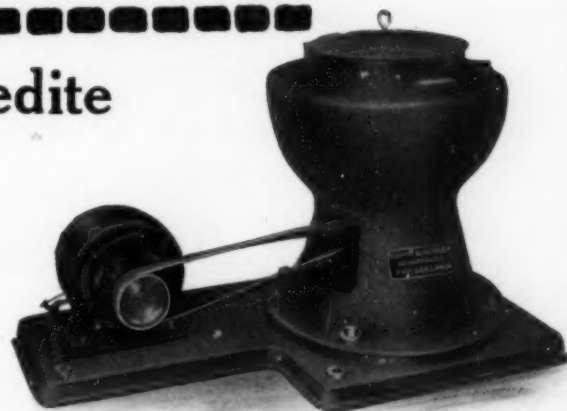
OUR New model, electrically driven, is the ideal machine. The bowl is but 12" in diameter, and both motor and machine are compactly mounted on a single base.

Three machines in one are at your service. Use it as a self-balanced machine, with perforated bowl, as a rigid bearing machine with separator bowl for separating liquids of different densities, or fit it for use with a bottle holder for precipitating samples in bottles.

General excellence and "workability" of this machine are guaranteed by a half century of the large Schaum & Uhlinger Centrifugals.

Your request for information does not obligate you in any way.

SCHAUM & UHLINGER, INC.
Glenwood Avenue & Second Street
Philadelphia

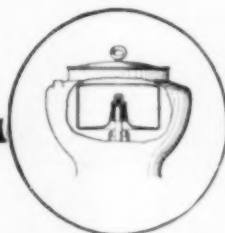


Schaum & Uhlinger LABORATORY CENTRIFUGAL

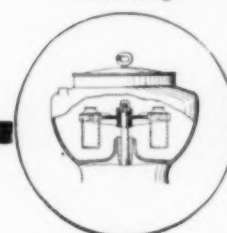
Extractor



Separator



Centrifuge



Tolhurst Centrifugals

For the Extraction of Chemicals at High Speeds

They can be kept going by unskilled help and with the minimum of attendance.

The self-balancing principle of the "Tolhurst" is a "Safety-first" factor which takes care of unbalanced loads while the machine is moving at top speed. No devices, springs or rubbers to get out of order, gravity alone controlling it on standard Tolhurst Centrifugals.

Patented adjustable idlers make the Tolhurst adaptable to any change of drive, i. e. floor to ceiling, counter belt to motor belt, to engine, etc.

Our Laboratory, Engineers and Salesmen are at your command without obligation.

Let us help solve your problem.

Tolhurst Centrifugals range in size from 12" to 72". All styles. Over or underdriven and suspended.



"Buy a 'TOLHURST' and Play Safe"

TOLHURST MACHINE WORKS, TROY, N. Y.

Are You Separating Solids From Liquids ?

*Let Us Show You How
a Specially Built
Machine Will Help You*

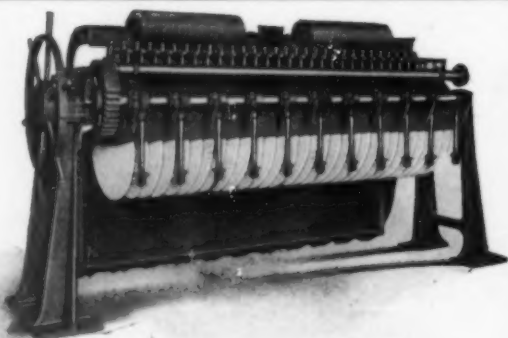
—whether yours is a filtration, dewatering or accelerated settling problem.

Turn that problem over to our chemists and engineers. They will show you where you can apply greater efficiency to your production. Their survey will bring you a preliminary report.

The machine we can build you on the basis of that report means efficiency engineering applied to your work.

Write!

International Filtration Corporation
115 Broadway, New York



Every Leaf is Accessible

Do you realize the importance of this feature? It means that when the filter is opened, from a position alongside the filter, every leaf is in full view. No guess work—the operator always knows the true condition of the entire press.

The Sweetland Self Dumping Filter

is self-dumping, requires less hand labor, uses less wash water. It is the modern filter for the modern plant.

Booklet on Request

Sweetland Filter Press Co., Inc.
926 Singer Building, New York

Makers of Sweetland's Patent Metallic Filter Cloth



FILTER PRESSES

Laboratory Press, designed for making practical tests.

We build Iron Plate and Wood Plate Presses in all sizes from 12 inches to 40 inches.

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information
and prices*

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The Moore Vacuum Filtration Process

Fully protected by patents

Will Enable You to Save All Values Reduced to Solution and Recover the Solvent at Minimum Cost.

We are pioneers in the field—we developed the only really successful process, and we are still

THE LEADERS IN FILTER DESIGN

Send Your Specifications or Submit Your Problem to the

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Cable:
"Morefilter" New York

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any Standard Code

KELLY FILTER PRESS—

PATENTED

*It Produces a Better Product
at Lower Cost*



Here are the reasons:

Cakes can be discharged in dry and compact form; the low moisture means a saving in steam and values.
Cakes are of even thickness and permeability, therefore a complete wash with least amount of water is obtained.
One man can take care of several presses. Every square inch of filter area is fully exposed to the view of the operator, and all parts of this press are accessible.

We furnish these presses Copper, Lead and Nickel lined, and cast of Brass, Copper, Phosphor Bronze and Monel Metal. Also jacketed to keep presses hot or cold.

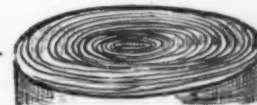
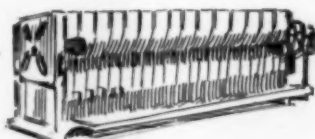
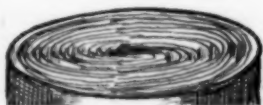
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and investigate.*

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NEW YORK: EMIL E. LUNGWITZ, 30 CHURCH STREET

Kelly Filter Press Company, Salt Lake City, Utah

BERLIN: A. L. Genter, Friedrichstr. 60.



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A Sample of **HUYCK** Filter Press Fabrics

We want you to test HUYCK WOVEN WOOLEN FABRICS for the following reason:

We have made woven woolen endless felt for the severe requirements of paper and pulp filtering. Our success in getting a fabric strong in fibre, even in texture and able to resist friction in this work insures unusual quality in all our filter fabrics.

Prove this for yourself. Send us a sample of your cloth, and we will duplicate it. Then compare the results you get with our cloth with your present filtering experiences.

Write!

F. C. HUYCK & SONS

KENWOOD MILLS, ALBANY, N. Y., U. S. A.



Insure Purity of Product During Heating

Distill or evaporate in

Elyria

Glass Enameled Apparatus

Has the acid-resistance of Chemical glass and the strength of steel

The enamel is fused to *Seamless One-Piece* welded steel at 2000° Fahr.

We build plain, steam jacketed and water jacketed kettles, agitating and mixing apparatus, vacuum pans, stills and

Plain Welded Tanks—Not Enameled

These tanks represent extra high-grade work. The welds are absolutely non-porous. Practically the full strength of the solid plate.

Special equipment built for special working conditions. Write for the data and Catalog.

The Elyria Enameled Products Co.
Elyria, Ohio

New York Office: 50 Church Street

The Golden Crown Vacuum Still



—with or without mixing apparatus
—plain or porcelain lined throughout

A product of 75 years of apparatus making experience. We are the oldest house in the United States in the enameling business.

This insures acid proof apparatus whose lasting qualities will reduce your costs.

We build the following either with acid proof porcelain on cast iron or in plain iron:

Vacuum Stills,
Steam Jacketed Kettles,
Evaporating Dishes,
Storage Cans,
Tanks,

Nitrating Stills,
Autoclaves,
Retorts,
Annular Kettles,
Sterilizers.

Special apparatus built to order, plain or porcelain lined. Get on the list for our new Catalog, shortly off the press.

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NEWCOMB CARLTON, PRESIDENT

BELVIDERE BROOKS, VICE-PRESIDENT

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1302 Niagara Street,
Buffalo, New York.

Ship immediately fifty.

December 15th, 1915.

Use This Method of Getting Apparatus Quickly

Our customers are doing just that to secure on short notice DOPP

**Jacketed Kettles, Mixers,
Vacuum Pans**

You can have all the confidence in buying at long range because we *guarantee* every piece of apparatus we send out.

Dopp apparatus is *seamless*, one piece, without a rivet or a joint. Standard apparatus tested to 150 lbs. pressure. Special castings for higher pressures if necessary.

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Sowers Manufacturing Co.

1302 Niagara Street, Buffalo, N. Y.

39 Cortlandt Street, New York City



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L. O. KOVEN & BROTHER

JERSEY CITY, N. J.

Chemical

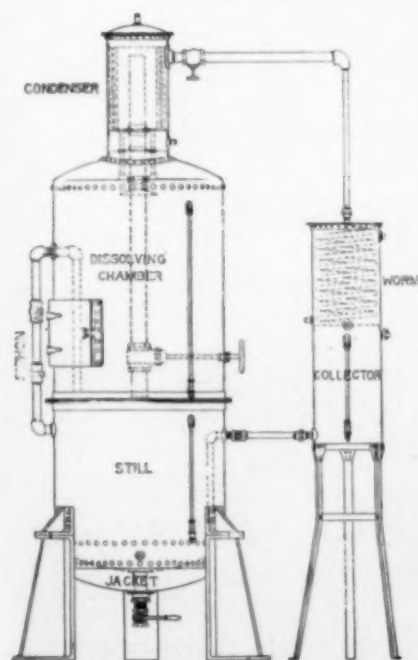
Metallurgical

Machinery

Apparatus

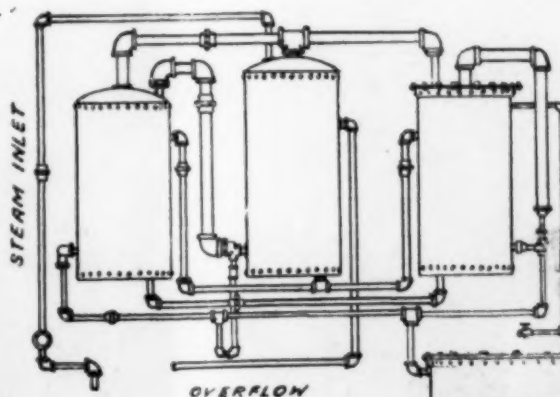
We feature Stills in this Ad.

Tho We Make { Whatever You Want
Whenever You Want It.



EXTRACTING STILL

This Still provides a means for dissolving solids with vapors and liquids of a volatile nature. It also provides for reducing the solution to a desired baumé, and for the recovery of the dissolvent.

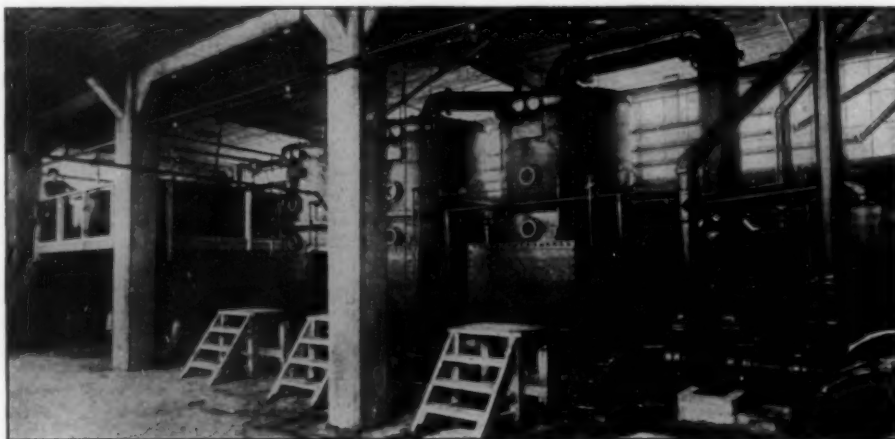


DISTILLED WATER

This apparatus is capable of providing distilled water from steam supplied, or by evaporating and then condensing, from water supply by City service.

STORAGE TANK

ZAREMBA PATENT EVAPORATOR



Built for LONG LIFE, HARD SERVICE and NO WORRY to its OWNER

The only apparatus that provides insurance against the results of carelessness and ignorance

SPECIAL TYPES FOR SPECIAL WORK

ZAREMBA COMPANY, Buffalo, U. S. A.

H. E. JACOBY, New York Agent, 95-97 Liberty Street



Don't Experiment if you have an evaporation problem

Let SWENSON ENGINEERING SERVICE, based upon the most advanced policy of co-operation, analyze your problem and reduce your cost of manufacture by the installation of modern equipment designed for your particular work. It will be handled by evaporation engineers of twenty years' experience, involving over 700 installations.

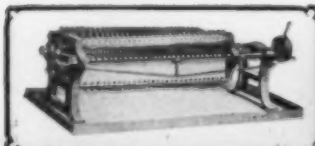
SWENSON EVAPORATORS

Find application in every branch of the Metallurgical and Chemical industries and our several types of evaporators of various capacities are concentrating numerous solutions successfully.

Our latest and most important improvement is A NEW TYPE FOR HIGH DENSITY WORK. With this apparatus you can economically concentrate solutions (whether crystallizing or not) much heavier than is possible in any commercial equipment previously offered.

SWENSON EVAPORATOR CO.

945 Monadnock Bldg., Chicago



FILTER

Superior in economy of operation and mechanical construction

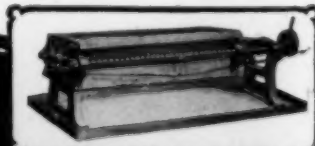


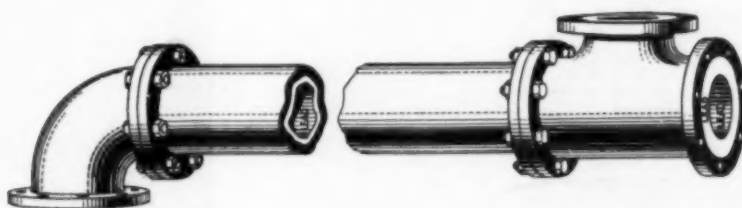
D. R. SPERRY & CO., Batavia, Ill.



PRESSES

Sperry Laboratory Presses save time and labor, and are most complete





Sweep Away Your Acid-Piping Problems with One Stroke

Install United Lead Lined Flanged Iron Pipe Fittings and Acid Proof Valves and forget that you ever had any troubles in this line.

*Catalog on
Application*

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LEAD CO.**

162 Congress Street, Boston, Mass.



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Platinum Plate, Sheet and Wire, either pure or alloyed with Iridium, in any grade of hardness.
Seamless Platinum Tubing in all dimensions.

Platinum for all purposes as required by Chemists, Metallurgists, Druggists, Physicists, Schools, Colleges, Chemical Supply Houses and Manufacturers.

We buy or exchange Platinum scraps, worn out dishes, etc.



NEW YORK OFFICE
CHARLES ENGELHARD
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Stoneware Pots for Acid and Other Corrosive Liquids

Made of thoroughly vitrified, glazed, in-corrodible, chemical stoneware. Pots for the storage of acids are tested to 7½ lbs. per square inch. They can be adapted for battery grouping with syphon connections.

**We Make a Complete Line
of Chemical Stoneware**

*Write for descriptive Catalog,
which gives prices.*



German-American Stoneware Works

Office, 50 Church Street, New York City
Factory, Keasbey, N. J.

Chemical Mechanical Apparatus

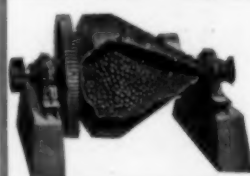
Acid Resisting Iron Castings,
Long Experience, High Quality,
Contract Deliveries Dependable

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Cable Address: Crescent, Elizabeth, N. J.
Codes A. B. C. 4th, Liebers, Western Union

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Manufacturer of
Acid-Proof Chemical Stoneware
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HARDINGE MILLS
FOR
**ECONOMICAL FINE
GRINDING**
HARDINGE CONICAL MILL CO.
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NEW YORK



The Ultimate Economy lies in Genuine Imported German Chemical Stoneware

HIGH GRADE EUROPEAN PORCELAIN WARE for chemical and electrochemical plants, laboratories, electrolytic refineries, etc.

ENAMELED CAST IRON APPARATUS (German Ware), acid-proof, durable, sticks firmly to metal, resists high temperatures. Made up to largest sizes.

HARD PORCELAIN BALL MILLS (German Ware), hand or power drive, for wet or dry grinding of quartz, feldspar clays, white lead, chemicals, drugs, spices or other materials.

ACID PROOF CEMENT, cement-mortar, not affected by cold or hot acid or lye—for lining vats, receivers, for tightening pipes, for acid towers—

wherever acid is handled. Eliminates necessity for lead.

DRY VACUUM PUMPS for the manufacture of incandescent lamps, gunpowder, explosives, etc. For exhausting air or gases through liquids. For chemical and sugar work and for use with impregnating machinery.

IMPORTED ACID BRICK made of Obsidianite (English Product), a perfectly vitreous non-absorbent material—impervious to acids; also fire-proof. We furnish the complete stoneware outfit for the manufacture of Nitric and Muriatic Acid, Denitration plants for mixed acids, plants for regeneration of nitric acid and also single apparatus for any purpose.

J. W. Sittig, Importer, Temple Court Bldg., New York



If you handle Acids—or Work at High Temperatures it's best to use

VITREOSIL *for* Chemical Plants

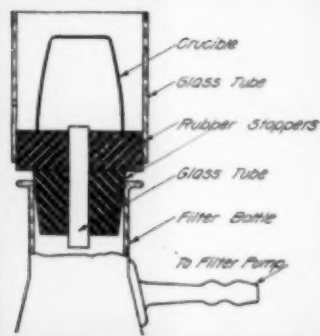
Vitreosil crucibles, dishes, tubes, etc., have proven their acid resisting and heat resisting qualities in the *laboratory*. Vitreosil in larger sizes will render the same service in the *plant*. Bring us your problems and we will give you expert service based on years of experience. This is a conservative statement, backed by real ability to supply apparatus that will solve your problems. Parts from stock or to order, in special designs. Over 700 Vitreosil Sulphuric Acid Concentration plants in service to-day. Write us.

The Thermal Syndicate, Ltd.

50 East 41st St., New York City

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In filtering, the precipitate is retained on the surface of the medium. Some of the very fine particles will occasionally penetrate below the surface.



To properly cleanse a filter an apparatus as illustrated can be made in the laboratory out of glass tubing and a rubber stopper.

By reversing the flow of the wash-water the filters are thoroughly cleansed and can be used repeatedly. We supply only the filters, which are made in three degrees of porosity. Our catalogue will tell you about them. Write for it.

782

NORTON COMPANY



WORCESTER, MASS.



ELECTRIC "HIGH TEMP"

FURNACE

1800° CENTIGRADE

Direct or Alternating Current
up to 125 Volts

At the National Exposition of
Chemical Industries

Operated 72 hours at 1400° to 1650°
C.: Maintenance cost four cents;
Held 1400° C constant, without reg-
ulation, on 1250 Watts, during 3 to
5 hours' duration.

Inquire direct or of dealers

ELECTRIC HEATING APPARATUS CO., 133-137 E. 16th St., N. Y.

Makers of

MULTIPLE REPLACEABLE UNIT FURNACES

Carried in stock by

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EIMER & AMEND
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LYMANS, Limited
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ARTHUR H. THOMAS CO.
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Riche Adiabatic Calorimeter

The simplest, most speedy and most accurate Calorimeter on the market

The Busy Chemist's Best Friend

A new lot just finished.

Reduction in price has also been
made.

Will send a calorimeter on
thirty days' trial to any place in
the U. S. A.



Lenz and Naumann, Inc.

"The Scientific Specialties Co."

Laboratory Supplies & Specialties

17 Madison Avenue, New York, U. S. A



For High Temperature Work

Testing Refractories
Fusing Coal Ash
Melting Alloys

HOSKINS ELECTRIC FURNACE

For testing materials of very high melting point such as fire clay, brick, refractories, etc.—

For fusing coal ash under conditions equivalent to actual furnace operation—

For crucible melting of metals and alloys, and numerous other purposes requiring temperatures between 530° C. and 2000° C.—

This carbon-plate-resistor Hoskins Electric Furnace has proved highly satisfactory. Built in eight sizes, with chamber capacities ranging from 31 to 3600 cubic inches, or capable of holding any size graphite crucible from No. 0000 to No. 60. Accurately controllable at any temperature within its range, absolutely quiet, clean and safe. Our Bulletin No. 12 gives full information.

Hoskins Manufacturing Company Electric Furnaces, Pyrometers and Chromel Resistor Material.

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E. H. Sargent & Co., Chicago; A. H. Thomas Co., Philadelphia;
Bausch & Lomb Optical Co., Rochester;
Henry Heil Chem. Co., St. Louis;
Scientific Materials Co., Pittsburgh.

Another Laboratory Convenience

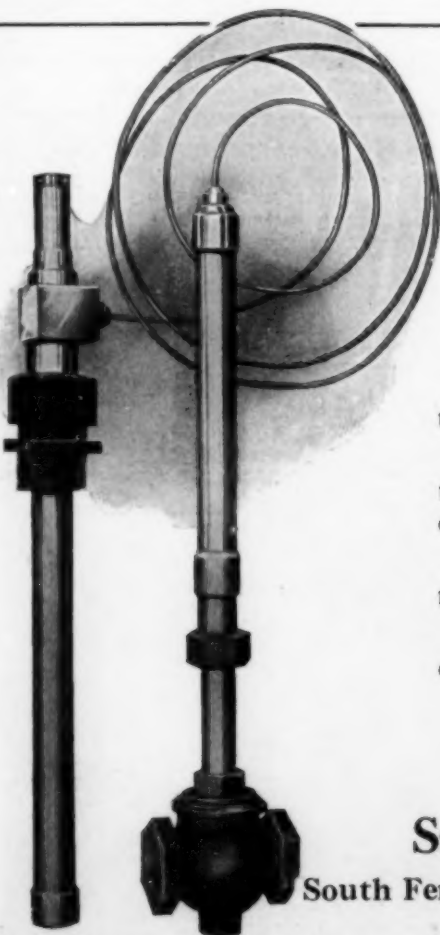
Every laboratory needs a pair of non-corrosive, acid-resisting tongs for handling hot platinum ware. These

Solid Nickel Tongs—Chromel Tips

meet every requirement at a fraction of the cost of the platinum tongs which they have replaced in hundreds of laboratories. Solid forged nickel, eight inches long, double bent style, heavy Chromel tips. Price \$2.50. Order a pair today.



505



TEMPERATURE REGULATOR "SARCO"

Turn over the heat control of your liquids or air to the SARCO REGULATOR.

The thermostatic fluid which it contains regulates the controlling valve with exactness. Temperatures cannot rise above a predetermined point.

The "Sarco" is self-operating. Does away with the need of electricity, compressed air, etc.

In extensive use in dye houses, gas producers, gas condensers, ammonia stills, chemical factories, etc.

WRITE US.

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Sarco Engineering Company

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It is right at this point that the **every-issue** advertiser profits by his preparedness.

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—that the **non-advertiser** loses.

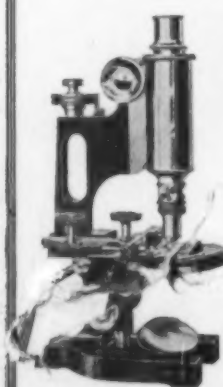
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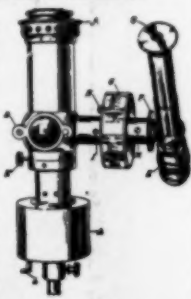
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For Hardness Testing

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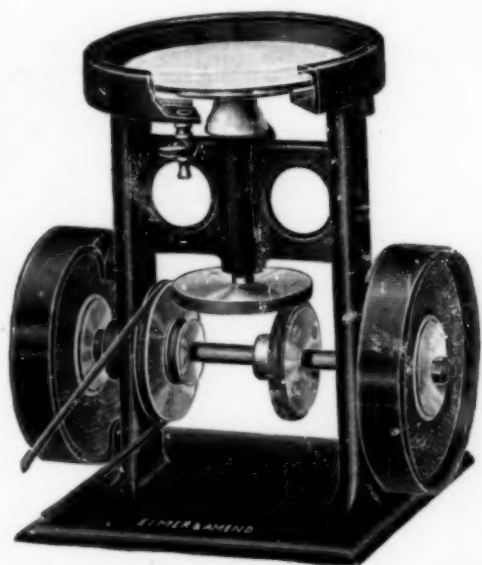


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Wysor's Combined Grinding and Polishing Machine

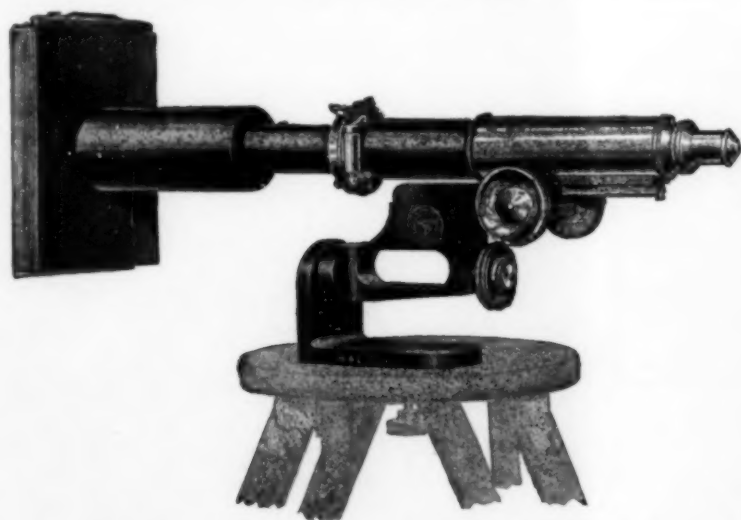


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Write for copy of catalog M-CB "Apparatus for Metallography," in which this machine and its application is fully described

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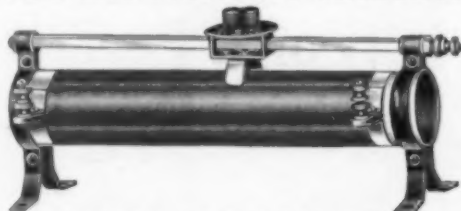
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at

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We own and offer for sale all of the following material which was in use at the Jack Rabbit mill, 40 miles south of Casa Grande, Ariz. This material will be loaded at that station and attractive prices will be made rather than move to Denver. In addition to the following list there is a complete line of supplies such as packing, pipe, valves and fittings, electrical goods, tackle blocks, oils, greases, etc. The large pump has never been used and balance of equipment very little.

- 13 & 21 & 34 x 10 x 24 Prescott Triplex Expansion Pot Valve Station Pump with 10 x 16 x 18 Independent Air Pump and Condenser. Extra valve seats, valves, springs and parts. This pump has never been used. Just as it came from the factory, never set up.
- 18 x 10 x 18 Prescott Chandler Type Duplex steam outside end packed.
- 14 x 6 x 12 Prescott Duplex Sinking Pump.
- 2—No. 9-B. Cameron Sinkers, 14 x 7 x 13.
- 1—No. 7 Cameron Sinkers, 10 x 5 x 13.
- 1—3 x 2 x 3 Fairbanks-Morse Duplex Pump.
- 1—6 x 4 x 6 Fairbanks-Morse Duplex Pump.
- 1—16 x 18 x 111 x 16 Sullivan Air Compressor, Type WB-2, 703 feet.
- 1—42 x 10 Air Receiver.
- 6 x 8 Ray & Titcomb Geared Hoist.
- 10 x 12 Ray & Titcomb Geared Hoist, Steam Winch and hand winch.
- 18" x 10 Schumacher & Boyd Engine Lathe with 16" Universal chuck.
- 1½ to 6 inch Williams Tools Co. Power pipe threading machine. No. 3 Buffalo Drill Press. Hand pipe tools.
- 250 HP. 150 W. P. International Fire Box Boiler.
- 250 HP. 150 W. P. International Fire Box Boiler.
- 150 HP. 110 W. P. Return Tubular Horizontal Boiler.
- 60 HP. 125 W. P. International Fire Box Boiler.
- 50 HP. 100 W. P. Ames Locomotive Portable Boiler.
- 1—20,000 gal. Galv. Iron Water Tank.
- 1—10,000 gal. Galv. Iron Oil Tank.
- 1—30,000 gal. Steel Oil Storage Tank.
- 1—35 BBL. Round steel tank.
- 4—20 Steel wagon tanks.
- 13—13 BBL. Steel wagon tanks.
- 2—2½ inch wagons without bed.
- 1050 Bbls. Fuel oil.

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Have You Any Scrap Platinum, Gold, Silver, or other precious metals?

We Pay Highest Prices

Estimate or remittance by return mail.

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Taylor Chemical Co., Penn Yan, N. Y.

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of the *NEED* for the Searchlight Section is the large number of requests constantly received by the publishers for information as to where second-hand machinery or certain services can be obtained.

The Searchlight Section

is now the market place where these wants can be made known and filled.

Get Your Wants into the Searchlight

POSITIONS WANTED

METALLURGICAL and chemical engineer, nine years' experience, at present employed, desires position as department superintendent or technical assistant to a manager. Blast furnace, open hearth, rolling mill experience, supplemented by work on lubrication, electric furnace practice and efficiency work. Box 476, Met. & Chem. Eng.

CHEMIST, graduate, 24, with three years' general analytical experience, at present employed in nitro-cellulose and acid manufacture, desires a change. Can furnish high class references. Position must be in vicinity of New York City. Box 483, Met. & Chem. Eng.

POSITIONS VACANT

ACID plant manager who understands the manufacture of nitric, hydrochloric and sulphuric acids. Give full details of record and experience. State salary expected. All communications will be considered confidential. Box 482, Met. & Chem. Eng.

WANTED—Young metallurgist, must be thoroughly familiar with up-to-date Metallography and Pyrometry, excellent opportunity for capable man with initiative. State nationality, age, education, experience, whether able to read German or not, give reference, and state what salary would be desired to start. Box 479, Met. & Chem. Eng.

CHLORINE man wanted. Chemist with experience in manufacturing chlorine products by an old established chemical company for a new department. Unlimited opportunity for one who knows, and who can demonstrate his ability. Experience—and ambition—are sure to win rapid promotion in this position. Box 480, Met. & Chem. Eng.

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Positions Wanted, Evening Work Wanted, 2 cents a word, minimum charge 50 cents an insertion, payable in advance.

Positions Vacant, Salaries Wanted, Agencies, all undisplayed Miscellaneous ads, Machinery and Plants For Sale (with one line of display heading), 3 cents a word, minimum charge \$1.50 an insertion.

All advertisements for bids cost \$2.40 an inch.

Advertisements in display type cost as follows for single insertions:

1-16 page, \$5.00	1 in. single col., \$3.00
1-8 page, 10.00	4 in. single col., 11.60
1-4 page, 20.00	8 in. single col., 22.40

In replying to advertisements, send copies of testimonials, etc., instead of originals.

POSITIONS VACANT

WANTED—Chemical Engineer or Metallurgical Chemist familiar with commercial production of tungstic acid or metallic tungsten. Some one familiar with plant apparatus and machinery preferred. Big opportunity for right man. Reply to Box 478, Met. & Chem. Eng.

MISCELLANEOUS

Back Volumes Wanted

Back volumes Electro-Chem. Industry, Electro-Chem. & Metall. Industry, Metall. & Chem. Engineering. Set preferred. Journal Physical Chemistry, set or volumes; Chem. Abstracts, 1907, Nos. 11 and 12, 1910 complete. Jour. Ind. & Eng. Chem., 1910 complete. Jour. Amer. Chem. Soc., 1905 Jan.-Aug., 1906 Jan.-March, Aug. 1910 complete; offers. Box 105, Merchants Station, St. Louis, Mo.

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Wanted. Analytical balances, laboratory apparatus, microscope, electrical apparatus, etc., for addition in a commercial laboratory. Must be in good condition. Would also like to buy glass apparatus, glassware, and other laboratory accessories. Send full description and price wanted to A. B. Werby, 108 Howland Street, Roxbury, Mass.

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Advertisements in it

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Acid Eggs

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Alundum

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Williams Apparatus Company.

Anodes, Graphite

Acheson Graphite Co., Int'l.

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Chemical Construction Co.
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Knight, M. A.
Sittig, J. W.

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Moore, Sam'l L., & Son.
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Merck & Co.
Solvay Process Co.
Taylor Chemical Co.
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Chemists and Chem. Engrs.

See Professional Directory, Pages 62-63.

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Solvay Process Co.
Warner Chemical Co.
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Caldwell, H. W., & Son Co.
Duriron Castings Co.
Werner & Pfleiderer Co.

Copper, Silicon & Manganese

Electric Smelt. & Alum. Co.

Crane & Hoist Controllers

Cutler Hammer Clutch Co.

Crucibles

Acheson Graphite Co., Int'l.
Bartley, Jonathan, Crucible Co.
Duriron Castings Co.
Gantier, J. H., & Co.
Thermal Syndicate, Ltd.

Crushers and Grinders

Abbé Eng'g Co.
Abbé, Paul O.
Aero Pulverizer Co.
Chalmers & Williams.
Colorado Iron Works Co.
Fardine-Conical Mill Co.
Kent Mill Co.
Krupp (Froesser & Son).
Power & Mining Machinery Co.
Raymond Bros. Imp. Pulv. Co.
Sturtevant Mill Co.

Crushers, Grdrs. Pulv., Lab.

Abbé Eng'g Co.
Abbé, Paul O.
Elmer & Amend.
Hardinge Conical Mill Co.
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Cupola Blocks: See Blocks, Cupola

Cupola Furnaces, Foundry

Power & Mining Machinery Co.

Cyanide Machinery

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Cyanide, Quicksilver

Zinc Dust
Atkins, Kroll & Co.

Diffusion Batteries

Lummas, W. E.
Swenson Evaporator Co.

Disasters

Elyria Enamelled Products Co.
Koven, L. O., & Bro.
Stuart & Peterson Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.

Distilling Machy. Apparatus

Badger, E. B., & Sons Co.
Elyria Enamelled Products Co.
Koven, L. O., & Bro.
Lummas, W. E.
Stuart & Peterson Co.
Werner & Pfleiderer Co.
Zaremba Co.

Dry Blast Plants

Carrier Engineering Corporation.

Dry Cell Filler

Acheson Graphite Co., Int'l.

Dryers, Centrifugal

American Tool & Mach. Co.
Schau & Uhlinger, Inc.
Tollhurst Mach. Works.

Dryers, Vacuum

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Drying Mach. & Apparatus

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American Process Co.
Buffalo Forge Co.
Buffalo Fdy. & Machine Co.
Day, J. H., Co.
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Ruggles Coles Eng'g Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.

Dust Collectors

Knickerbocker Co.
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Dynamos, Electroplating

See Electroplating Dynamamos; Supplies

Dynamamos and Motors

Bogue, C. J., Elect. Co.
Janta & Leist Elect. Co.
Westinghouse Electric & Mfg. Co.

Electric Cranes: See Cranes

Electric Mono-Rail Systems

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Electric Furnaces

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Electric Furnaces, Lab'y

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Electrical Testing Sets

American Transformer Co.

Electrodes, Carbon

Acheson Graphite Co., Int'l.
National Carbon Co.

Electrodes, Graphite

Acheson Graphite Co., Int'l.

Electrodes, Platinum

American Platinum Works.
Baker & Co., Inc.
Engelhard, Chas.

Electrolytic Cells

Warner Chemical Co.

Electroplating Dynamamos: Supplies

Bogue, C. J., Elect. Co.
Janta & Leist Elect. Co.

Enam. Cast Iron Apparatus

Acid Proof
Sittig, J. W.

Engineers, Chemical, Consulting, Analytical, Industrial

Process Engineering Co.
Williams Apparatus Company.

Engineers, Consulting

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Engineers, Combustion

Improved Equipment Co.

Engineers, Construction

Chemical Construction Co.

Engineers, Furnace

Quigley Furnace & Foundry Co.
Rockwell, W. S., Co.

Engines, Steam

American Blower Co.

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Morse Bros. Mach. & Equip. Co.

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Devine, J. P., Co.
Jacoby, Henry E.
Lummas, W. E.
Sowers Manufacturing Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Zaremba Co.

Extractors
Lummas, W. E.**Fans**American Blower Co.
Buffalo Forge Co.
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Knight, M. A.**Ferro-Alloys**Goldschmidt Thermit Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.**Fertilizer Plants**

Process Engineering Co.

Filter Cloth

Huyck, F. C., & Sons.

Filter PressesColorado Iron Works Co.
Day, J. H., Co.
Int'l Filtration Corporation.
Jacoby, Henry E.
Kelly Filter Press Co.
Koven, L. O., & Bro.
Lungwitz, Dr. E. E.
Moore Filter Co.
Perrin, Wm. R., & Co.
Shriver, T., & Co.
Sterry, D. R., & Co.
Sweetland Filter Press Co.
Werner & Pfeiderer Co.**Filter Press Distill' Grains**
Swenson Evaporator Co.**Filtering Media**

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Norton Co.**Filters, Water: See Stills****Fire Brick and Clay**Foot Mineral Co.
Gautier, J. H., & Co.
Kieselguhr Co. of America.
Maurer, Hy., & Son.**Fluorspar**

Lavino, E. J., & Co.

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Maurer, Hy., & Son.**Furnace Linings, Graphite**
Acheson Graphite Co., Int'l.**Furnace, Chloridizing and Sulfating**
Wedge Mechanical Furnace Co.**Furnaces, Cupola, Foundry**
Power & Mining Machy. Co.**Furnaces, Electric**Metal Refining or Melting
Betts, Anson G., & Co.
Hamilton & Hansell.
Leavitt, C. W., & Co.**Furnaces, Electric, Lab'y**
Electric Htg. Apparatus Co.
Elmer & Amend.
Engelhard, Chas.
Hoskins Mfg. Co.**Furnaces, Heat Treating**
Electric Htg. Apparatus Co.
Engelhard, Chas.
Hoskins Mfg. Co.
Quigley Furnace & Foundry Co.
Rockwell, W. S., Co.
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Oil, Gas or Powdered Coal

Rockwell, W. S., Co.

Furnaces, MuffleElectric Htg. Apparatus Co.
Engelhard, Chas.
Hoskins Mfg. Co.
Improved Equipment Co.
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Wedge Mechanical Furnace Co.**Furnaces, Smelting**Colorado Iron Works Co.
Koven, L. O., & Bro.
Pacific Foundry Co.
Wedge Mechanical Furnace Co.**Furnaces, Sulphur**Foundry Co.
Wedge Mechanical Furnace Co.**Furnaces, Welding**

Quigley Furnace & Foundry Co.

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Morgan Const. Co.
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Schaeffer & Budenberg Mfg. Co.
Taylor Instrument Co.
Thwing Instrument Co.**Gears**

Caldwell, H. W., & Son Co.

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Glass Blowing

Elmer & Amend.

Graphite

Acheson Graphite Co., Int'l.

Grinders

See Crushers and Grinders

Grinding Wheels

Norton Co.

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Griscom-Russell Co.

Heating ApparatusAmerican Blower Co.
Buffalo Forge Co.**Hydro Extractors**American Tool & Mach. Co.
Schau & Uhlinger, Inc.
Tolhurst Mach. Wks.**Hydrogen Plants**

Improved Equipment Co.

Instruments, Electrical and TestingBristol Co., The.
Chicago Apparatus Co.
Elmer & Amend.
Engelhard, Chas.
Hoskins Mfg. Co.
Leeds & Northrup.
Sauveur & Boylston.
Schaeffer & Budenberg Mfg. Co.
Shore Instrument Co.
Sturtevant Laboratories.
Taylor Instrument Co.
Thwing Instrument Co.
Westinghouse Electric & Mfg. Co.**Insulating Material, Heat**

Kieselguhr Co. of America.

Jars, Acid Storage

Knight, M. A.

Jets and Nozzles, Acid Proof

Duriron Castings Co.

Joints

Goldschmidt Thermit Co.

Kettles, Acid Proof

Duriron Castings Co.

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Koven, L. O., & Bro.
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U. S. Cast Iron Pipe & Fdy. Co.
Werner & Pfeiderer Co.**Kettles, Steam-Jacketed**Buffalo Fdy. & Machine Co.
Elyria Enamelled Products Co.
Stuart & Peterson Co.
Werner & Pfeiderer Co.**Kettles, Stoneware**Ger.-American Stoneware Works.
Knight, M. A.**Kiln, Lime**

Improved Equipment Co.

Kiln, Rotary & Nodulizing

American Process Co.

Laboratory SuppliesBausch & Lomb Optical Co.
Central Scientific Co.
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Gaertner, Wm., & Co.
Hoskins Mfg. Co.
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Werner & Pfeiderer Co.**Machinery, Classifying**

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Dorr Cyanide Machinery Co.
Dwight & Lloyd Sintering Co.
General Filtration Co., Inc.
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Kelly Filter Press Co.
Kent Mill Co.
Krupp (Prosser & Son).
Lungwitz, Dr. E. E.
Morse Bros. Mach. & Supply Co.
Pacific Foundry Co.
Power & Mining Machinery Co.
Raymond Bros. Imp. Pulv. Co.
Ruggles, Coles Eng'g Co.
Sturtevant Mill Co.
Sweetland Filter Press Co.
Wedge Mechanical Furnace Co.**Machinery, Mixing and Kneading**Abbé Eng'g Co.
Abbé, Paul O.
Buffalo Fdy. & Mach. Co.
Day, J. H., Co.
Dunning, W. D.
Koven, L. O., & Bro.
Power & Mining Machinery Co.
Sowers Manufacturing Co.
Werner & Pfeiderer Co.**Machinery, Pulverizing**Abbé Eng'g Co.
Abbé, Paul O.
Aero Pulverizer Co.
Chalmers & Williams.
Day, J. H., Co.
Dunning, W. D.
Hardinge Conical Mill Co.
Kent Mill Co.
Krupp (Prosser & Son).
Power & Mining Machinery Co.
Raymond Bros. Imp. Pulv. Co.
Sturtevant Mill Co.**Machinery, Soap**

Dunning, W. D.

Machinery, Special

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Machinery, Sugar Centrifugals

American Tool & Mach. Co.

Machinery Thickening and DewateringDorr Cyanide Machinery Co.
Werner & Pfeiderer Co.**Machinery, Wood Pulp**

Swenson Evaporator Co.

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Cutler Hammer Clutch Co.

Magnetic Disc Brakes (direct current)

Cutler Hammer Clutch Co.

Magnetic Separators

Cutler Hammer Clutch Co.

MagnesiteFoot Mineral Co.
Levensaler-Spicer Corporation.**Magnesium Metal**

Aviation Materials Corp'n.

Leavitt, C. W., & Co.

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Sauveur & Boylston.

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Dorr Cyanide Machinery Co.
Dwight & Lloyd Sintering Co.**Metals**Goldschmidt Thermit Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.**Microscopes**Bausch & Lomb Optical Co.
Elmer & Amend.
Sauveur & Boylston.**Mills, Ball, Pebble and Tube**Abbé Eng'g Co.
Abbé, Paul O.
Chalmers & Williams.
Colorado Iron Works Co.
Hardinge Conical Mill Co.
Krupp (Prosser & Son).
Sittig, J. W.**Mills, Conical**

Hardinge Conical Mill Co.

Mills, Emery

Sturtevant Mill Co.

Minerals

Foot Mineral Co.

Molybdenum Ore

Foot Mineral Co.

Monel Metal

Supple-Biddle Hdwe. Co.

Montejus, Automatic

Bethlehem Fdy. & Mch. Co.

Buffalo Fdy. & Mach. Co.

Motor Speed Regulators

Cutler Hammer Clutch Co.

Motor Starters

Cutler Hammer Clutch Co.

Muffles, Alundum

Norton Co.

Multiple Effect Distillg. App.

Swenson Evaporator Co.

Nozzles, Spray

Buffalo Forge Co.

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Lavino, E. J., & Co.

Packing, Acid-Proof: Tower

Knight, M. A.

Paint Pigment, Graphite

Acheson Graphite Co., Int'l.

Pans, Crystallizing

Knight, M. A.

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Bausch & Lomb Optical Co.

Pipe, Cast Iron

U. S. Cast Iron Pipe & Fdy. Co.

Pipe & Fittings, Acid Proof

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Duriron Castings Co.

Elyria Enamelled Products Co.

German-American Stoneware Wks.

Knight, M. A.

Stuart & Peterson Co.

Thermal Syndicate, Ltd.

Pipe & Fittings, Lead, Tin or Silver Lined

Badger, E. B., & Sons Co.

Chadwick-Boston Lead Co., The.

Platinum

American Platinum Works.

Baker & Co., Inc.

Elmer & Amend.

Engelhard, Chas.

Plug Cocks: See Cocks, Acid Proof**Porcelain Ware**

Bausch & Lomb Optical Co.

Sittig, J. W.

Pots, Acid Proof

Duriron Castings Co.

Knight, M. A.

Moore, Sam'l L., & Son.

Werner & Pfeiderer Co.

Powdered Coal Plants, Complete

Quigley Furnace & Foundry Co.

Power, Electric

Mississippi River Power Co.

Power Transmission Machinery

American Tool & Mach. Co.

Pulverizers, Laboratory

See Crushers, Grinders, Pulverizers, Laboratory

Pulverizing Machinery

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Pumps, Acid

Devise, J. P., Co.

Duriron Castings Co.

German-American Stoneware Wks.

Knight, M. A.

Process Engineering Co.

Sittig, J. W.

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Pumps, Centrifugal
Durlon Castings Co.
Pelton Water Wheel Co.

Pump Controllers
Cutler Hammer Clutch Co.

Pumps, Gas, Liq. or Vacuum
Abbé Engineering Co.
Buffalo Fdy. & Mach. Co.
Connersville Blower Co.
Devine, J. P., Co.
Nash Engineering Co., The.
P. H. and F. M. Roots Company.
Sittig, J. W.

Pumps, Rotary, Oil or Water
Connersville Blower Co.
Pelton Water Wheel Co.
P. H. and F. M. Roots Company.
Quigley Furnace & Foundry Co.

Pyrites
Lavinio, E. J., & Co.

Pyrometers
Bristol Co., The.
Elmer & Amend.
Engelhard, Chas.
Hoskins Mfg. Co.
Leeds & Northrup.
Schaeffer & Budenberg Mfg. Co.
Shore Instrument Co.
Stupakoff Laboratories.
Taylor Instrument Co.
Thwing Instrument Co.

Pyrometer Protection Tubes
Carbofrax, Refrax & Silfrax
Thermal Syndicate, Ltd., The.

Pyrometer Sheets, Graphite
Acheson Graphite Co., Int'l.

Pyroscope
Shore Instrument Co.

Quartz Glass
Elmer & Amend.
Engelhard, Chas.

Radium
Elmer & Amend.
Lens & Naumann.

Railways, Industrial & Portable
Easton Car & Construction Co.
Lakewood Engineering Co.

Rare Minerals and Ores
Atkins, Kroll & Co.
Foote Mineral Co.
Lavinio, E. J., & Co.
Leavitt, C. W., & Co.
Barlow, Willmarth O.

Recorders, CO.
Sarco Engineering Co.

Recording Instruments, Pressure, Temperature, Electricity, Motion, Speed, Time
Bristol Co., The.
Engelhard, Chas.
Hoskins Mfg. Co.
Leeds & Northrup.
Schaeffer & Budenberg Mfg. Co.
Taylor Instrument Co.
Thwing Instrument Co.

Refractories
Foote Mineral Co.
Kieselguhr Co. of America.
Maurer, Hy., & Son.
Norton Co.

Regulators, Automatic Humidity
Carrier Engineering Corp.

Regulators, Pressure
Connersville Blower Co.
P. H. and F. M. Roots Company.

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Retorts
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Gautier, J. H., & Co.

Retorts, Acid
Buffalo Fdy. & Mach. Co.

Rings, Chemical
Knight, M. A.

Rotary Converters
Westinghouse Electric & Mfg. Co.

Rutile
American Rutile Co.

Scales, Weighing
Werner & Pfleiderer Co.

Scleroscope
Shore Instrument Co.

Screens
Colorado Iron Works Co.
Day, J. H., Co.
Kent Mill Co.
Power & Mining Machinery Co.
Sturtevant Mill Co.
Tyler, W. S., Co.

Scrubbers, Gas
Buffalo Forge Co.

Separators, Air
Aero Pulverizer Co.
Raymond Bros. Imp. Pulv. Co.

Separators, Centrifugal
American Tool & Mach. Co.
Schaum & Uhlinger, Inc.
Tolhurst Mach. Wks.

Silica, Fused
Engelhard, Chas.
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Sluiks, Acid-Proof, Stone-ware
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Dwight & Lloyd Sintering Co.

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Chalmers & Williams.

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Badger, E. B., & Sons Co.
Elmer & Amend.
Lummus, W. E.
Sargent, E. H., & Co.
Werner & Pfleiderer Co.
Zaremba Co.

Stirrers
Acheson Graphite Co., Int'l.
Durlon Castings Co.
Werner & Pfleiderer Co.

Stoneware, Chemical
German-American Stoneware Wks.
Knight, M. A.
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Stoppers, Carboy
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Glens Falls Machine Works
Valley Iron Works.

Sulphur, Crude
Union Sulphur Co., The.

Sulphuric Acid Plants
Process Engineering Co.

Switchboards
Westinghouse Electric & Mfg. Co.

Synbons, Acid
German-American Stoneware Wks.
Knight, M. A.

Tachometer
Schaeffer & Budenberg Mfg. Co.

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Chadwick-Boston Lead Co., The.
Chemical Construction Co.
Elyria Enameled Products Co.
Knight, M. A.
Stuart & Peterson Co.

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Betts, Anson G., & Co.

Tanks, Electrolytic
Knight, M. A.

Tanks, Steel
Stevens Brothers.

Tanks, Storage
Chadwick-Boston Lead Co., The.
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Hauser-Stander Tank Co.
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Lummus, W. E.

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Thermit
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Thermometers
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Engelhard, Chas.
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Leeds & Northrup.
Lens & Naumann.
Schaeffer & Budenberg Mfg. Co.
Taylor Instrument Co.
Thwing Instrument Co.
Weinhagen, H.

Thermostats
Sarco Engineering Co.

Tile
Maurer, Hy., & Son.

Tile, Acid-Proof
Knight, M. A.

Titan Bronze
Titan Metal Co.

Titanium
Goldschmidt Thermit Co.

Titanium Ores
American Rutile Co.
Foote Mineral Co.

Towers, Acid Proof
Chemical Construction Co.
Durlon Castings Co.
Knight, M. A.
Thermal Syndicate, Ltd., The.

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Easton Car & Construction Co.
Lakewood Engineering Co.

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Westinghouse Electric & Mfg. Co.

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Traps, Steam
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Traps, Vacuum
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Sowers Manufacturing Co.
Werner & Pfleiderer Co.

Vacuum Pans
Badger, E. B., & Sons Co.
Buffalo Fdy. & Mach. Co.
Devine, J. P., Co.
Lummus, W. E.
Sowers Manufacturing Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Zaremba Co.

Vacuum Pumps
Crowell Mfg. Co.
Roots, P. H., & F. M. Co.

Valves, Acid-Proof
Durlon Castings Co.
Knight, M. A.

Valves, Vacuum
Sarco Engineering Co.

Vats, Acid-Proof
Durlon Castings Co.

Water Temperature Regulators
Sarco Engineering Co.

Water Wheels
Pelton Water Wheel Co.

Weighting Machines
Schaeffer Eng. & Equipment Co.
Sturtevant Mill Co.
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Welding Materials
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National Carbon Co.

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Lummus, W. E.
Zaremba Co.

Wood Tanks
Hauser-Stander Tank Co.

Zirconia
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New York

St. Louis

Rahway, N. J.

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